Commodities Price Cycles and their Interdependence with Equity Markets

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and
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Bringing Rigour and Evidence to Economic Policy Making in Africa

Commodities Price Cycles and their Interdependence with Equity Markets

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List of abbreviations and acronyms

AfDB	African Development Bank
BCOM	Bloomberg Commodities Index
BPI	Beverages Price Index
CARA	Constant Absolute Risk Aversion
CFTC	Commodities Futures Trading Commission
CAPM	Capital Asset Pricing Model
GC	Global Commodities
GDP	Gross Domestic Product
GFC	Global Financial Crisis
IRs	Information Ratios
JSE	Johannesburg Stock Exchange
MODWT	Maximal Overlap Discrete Wavelet Transform
MSCI-W	Morgan Stanley Capital International World Index
IMF	International Monetary Fund
MPI	Metals Price Index
FTSE	Financial Times Stock Exchange
TRs	Tracking Errors
WMC	Wavelet Multiple Correlation
WMCC	Wavelet Multiple Cross-Correlation
XWT	Cross-Wavelet Power Spectrum

Abstract

This study examines time-scale connectedness between returns on African stock markets and commodities across the energy, agriculture, metals, and beverage markets with wavelet-based coherency, wavelet multiple cross-correlation, and wavelet-based Sharpe ratio and generalized Sharpe ratio diversification analysis. We find evidence of increased performance of risk-minimizing portfolios during crisis that are broadly narrowed to long-run fluctuations (shorter scales). Such higher performances at shorter scales suggest that, during crises, investors show some levels of risk-aversion towards African equity investments over long term horizons. This explains why some African markets experienced first-round effect of the global financial crisis despite the theoretical view that African economies could potentially be decoupled from global economic shocks during crisis. Thus, although the decoupling phenomenon may hold for African markets during global financial crisis, if investors decide to balance their portfolios only for the short term, the portfolio reversals may cause serious effects to the continent. Further, of all the nine stock markets, it is only the Ivory Coast regional bourse that maximizes the multiple correlations against the linear combinations of the aggregate commodity indices. Lastly, the results confirm that having a combined portfolio of commodities and equities improves performance for different investment horizons.

Key words: Commodities markets; Co-movements; Multiscale analysis; Wavelets.

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1. Introduction

Broadly speaking, although commodities show equity-like characteristics, they tend to bear low to negative correlations with traditional asset classes like bonds and stocks. In the case of Africa, huge commodities endowment makes their economies highly dependent on commodities. At the same time, on account of their relatively less integrated nature, the continental economy has been deemed as partially segmented and therefore shows decorrelation with most global assets, including commodities. This is true for the continent's equity markets (Kodongo and Kalu, 2011). This provides hedging and diversification opportunities for global investors, a mechanism by which African countries can attract more investment capital.

Despite this common knowledge, there is always the need to regularly examine the evolution of the correlation pattern among related and unrelated asset classes, their contemporary patterns, and any noticeable dynamics for policy purposes. For example, to what extent does the dynamic relationship between African stocks and commodity prices hold discernible implications for equity-commodity investors seeking to diversify across uncorrelated assets? This paper examines the time-scale connectedness and risk sharing behaviour between returns on African stock markets and commodities. Although empirical research has examined the relationship between African stock markets and commodities, the short-term, medium-term and long-term sources of such relationships are overlooked. Such knowledge is needful to promote financial development in Africa and an expansion of African stock markets to attract more capital. Particularly, the story about the importance of financial markets and equity financing and stock markets in Africa as a tool for development cannot be complete without knowing specifically the details of how they might work in a portfolio and for which investor (hedgers, commodity dealers, food firms, etc.,) they are of interest – short-term, medium-term, or long-term. This also helps in the overall strategy and discourse of how to position African stocks as viable alternative vehicles in the global investments frontier.

Understanding the integration and connectedness among asset classes is central to research areas such as risk management, portfolio allocation, and business cycle analysis. Such studies do not just provide useful information to investors but also help policy makers to make sound decisions (Mensi et al, 2014). Knowing the correlation and risk sharing pattern of emerging stock markets with commodities is important because, primarily, the correlations between emerging stock markets and other asset classes constitute an important driver of the risk borne by international investors when deciding how to invest in a portfolio of dissimilar assets. The recommendations

by Bekaert and Harvey (2014) are that contemporary studies seeking to examine the integration or correlation of equity markets must include other asset classes such as currencies, commodities and bonds. This helps to provide useful information on the relative capacities of emerging equities in acting as viable alternatives to international investors seeking diversification away from global stocks.

Unlike the conventional correlation and multivariate GARCH analysis of African stock markets co-movements, this paper employs frequency-domain analysis using wavelet-based techniques; first, to examine commodity-equity markets co-movements and second, to investigate the significance of frequency domain analysis for portfolio and risk management through the estimation and comparison of frequency Sharpe Rations (SR) and generalized Sharpe Ratios (GSR) of commodity-equity portfolios.[1] The frequency dynamics is insightful for studying co-movements, as shocks with heterogeneous frequency responses create linkages with various degrees of persistence (Baruník and Krehlík, 2018). Such connections help in understanding possible sources of systemic risk that may remain hidden when aggregate measures are used. Using the time-scale measure helps to overcome such challenges; also partly because shocks to economic activity impact variables with different strengths and different frequencies. In financial markets, shocks arising from different investor expectations may exert impacts at different time scales. From the angle of portfolio investors seeking to hedge and diversify across different asset classes, day traders or hedge funds (short-term investors) are more concerned with co-movements at higher frequencies whereas big institutional investors (long-term investors) focus on the lower frequency. It is therefore important to, not only cater for the correlations, but also the investment horizons.

We examine the multi-scale (short-, medium-, and long-run) structural relationships between stocks and commodities using the bivariate wavelet coherence and wavelet multiple cross-correlation methods. Wavelets possess time-variant and time-frequency space features that are most suitable for exploring dynamic co-movement and interdependence among markets, through disintegration in the original series without any information losses. This then allows analysts to examine dominant channels of variability and to determine how those channels vary over time. It is instructive to note that this paper is not the first to apply wavelet techniques to the African stock market. Using the continuous Morlet wavelet transform, Boako and Alagidede (2017) establish that, the linkage between equity market returns in Africa on one hand and returns on commodities and exchange rates markets on the other hand are non-static and non-homogenous over time. In a related fashion, Omane-Adjepong and Dramani (2017) also apply wavelet to model the nature of regional and global connectedness of African stocks.

Although our paper is broadly related to Boako and Alagidede (2017) and Omane-Adjepong and Dramani (2017) for Africa, we extend the scope of these literatures by focusing on the time-scale behaviour across a broader set of commodities and African stocks and discuss how they influence the selection and allocation of assets for portfolios. The analysis also looks at portfolio diversification opportunities across

the two asset classes and draws inferences based on investors' horizons. In this regard, we add to the contribution by Bekiros et al (2016) and examine the portfolio performance of African stock markets with other commodities using wavelet-based diversified and undiversified portfolios. Here, we apply the wavelet test to calculate the scale-specific Sharpe ratios over different sub-periods in the sample to see how the risk-return characteristics of these different assets might have changed over time, rather than giving a one-shot look for the entire sample. This enables us to examine how risk-adjusted returns vary across these different periods. We believe analysis along these lines sets this paper apart from earlier works on Africa and contribute more significantly to the literature.

In addition, we use different indexes in combination with the wavelet multiple cross-correlation (WMCC) measure to identify any potential group leaders that could influence the other variables in the group. The methodology estimates overall correlations and cross-correlation within the multivariate framework across different time scales, making interpretation of the results easier, and offer further information over time horizons for the measured relationships – thus, knowing if the considered variables are characterized by short-to-long-term linkages (Ftiti et al, 2016).

2. Literature review

Commodities and equities: Theory and empirics

Contemporary literature is replete with how useful commodities have become for investors' hedging and risk mitigation strategies (see, for example, Gilbert, 2009; Yang and Garcia, 2014). In fact, the 2008 Commodities Futures Trading Commission (CFTC) report indicated that between the years 2000 and 2008 the extent of commodity futures markets investment inflows reached US$200 billion, and further rose to about US$210 billion by 2012.[2] Across diverse commodity markets also there were boom and bust cycles between 2007 and 2008 (Cheng and Xiong, 2013). According to Gorton and Rouwenhorst (2006), the significant investment inflows arose mostly because the inclusion of commodities futures has the potential to boost the diversification opportunities of investors since commodities have equity-like characteristics and tend to bear low to negative correlations with traditional asset classes like bonds and stocks. This has engendered greater interest of investors and researchers in considering the inclusion of commodities in similar portfolios.

The literature on linkages between commodities and equity markets can be analysed in different fashions. In one arm, the literature focuses on commodities cyclical unpredictability and their relationship with business cycles. For example, Labys et al (1999) evaluate the existence of a common driver of metal prices and associate this driver to some relevant macroeconomic cycles. Cashin et al (1999), in exploring the extent and length of commodity-price cycles, find that price-recession last longer than expansions. Roberts (2009) made similar observations by detecting peaks and troughs using 14 metals spanning 1947 to 2007 with duration dependence testing technique. He concludes that several of the durations of the phases were simple not random, but to a large extent cyclical. On the other hand, Morales et al (2011), applying GARCH and EGARCH, investigated the characteristics of unpredictability between precious metals and equity markets spanning 1995-2010 amid both Asian and the world financial crises. Their results reveal the presence of persistent volatility for the returns of precious metals, bidirectional volatility spread-overs, and demonstrated that gold drives other markets.

Another aspect of the literature which has gained prominence has been investment index and financialization of commodities. Empirical research lends evidence to how financialization has contributed to commodities and equities increased cross-market correlations during market downturns (Olson et al, 2014; Buyuksahin and Robe, 2014; Kablan et al, 2017). The commodity-equity correlations may also be driven by herd

behaviour (Demirer et al, 2015). Gilbert (2009) investigates the probability of price effect on the asset bubbles and index fund management on commodity futures price spanning 2006-2008. The results display evidence of projective behaviour of commodities, which is in line with speculative price effect. Tang and Xiong (2012) examine both the increasing index investment in commodities markets and their futures prices beginning from 2000s and find a statistically significant relation between them. They attributed this to the financialization process of commodity markets.

The final aspect of the literature deals with the relationship between commodity and stock market in a geographical context and in terms of exporting and importing countries. Notable among them is Morales (2008) who explores the characteristics of unpredictability spill-overs between commodities and returns of equities for G-7 economies spanning 1995-2006. The results reveal a long-lasting volatility effect from commodities to equity returns. Rossi (2012) studied the relationship between stock and commodities markets for exporting economies and finds evidence of a strong predictive power of exchange rate on commodities prices than stock market.

In terms of the application of wavelets to examine the dynamic relationships between commodities and equities, Boako and Alagidede (2017) establish, through the application of the three-dimensional continuous Morlet wavelet transform during the GFC, that equity markets in African economies, particularly those with large scale trading in one commodity or another, showed higher and noticeable connectedness with commodities. Closely linked to this study is the work by Bekiros et al (2016) that examined the commodity-equity relationship across energy, metals, and agricultural commodities and US equity returns. The authors establish evidence of significant inter-relationships between the two asset classes. Bekiros et al (2016) used wavelet coherence to evaluate the time-scale linkage between commodities and equity markets and concluded on the presence of a time-frequency causal relationship between the two markets in the USA.

3. Empirical strategies: Wavelet analysis

On account of the shortfalls of the pair-wise correlation and other several GARCH models used as core metrics for measuring integration and interdependence across markets (see, Pukthuanthong and Roll, 2009; Alexopoulos, 2017), focus has now shifted to more robust methods such as wavelet multiple correlation and cross-correlation approaches, as proposed by Fernandez-Macho (2012).

A wavelet transform creates time-frequency analysis of signals, and thus is able to estimate the spectral characteristics of signals as a function of time. Through wavelets, we generate both the power spectrum and also phase difference spectrum necessary for coherence (local correlation) analysis. The method also possesses time-variant and time-frequency space features that are most suitable for exploring dynamic co-movement and interdependence among markets, through disintegration in the original series without any information losses. This then allows analysts to examine dominant channels of variability and to determine how those channels vary over time. Generally, the frequency-based approaches allow for the understanding of any permanent interdependence (linkages premised on fundamentals) and transient market interdependence (thus, spill-overs resulting from excess linkages explained by shocks).

For this study, we choose to specify the continuous Morlet wavelet and its coherency model. The Morlet wavelet is the most popular among the mother wavelet family. According to Torrence and Compo (1998), its function has a zero mean and is localized in both time and frequency space. Hence, we adopt the use of the Morlet wavelet, and specify its function as:

$$\psi_0(\eta) = \pi^{-1/4} \ell^{iw_o\eta} \ell^{-\eta^2/2} \quad (1)$$

where, $\psi_0(\eta)$ is the wavelet function usually normalized to get unit energy; and parameters w_0 and η are, respectively, non-dimensional central frequency and time. The rate of rotation (in radians) per time unit w_0 is fixed at 6, as it gives a well-balance between frequency and time localization (Grinsted et al, 2004).

To determine possible interactions between pairs of markets, we propose using the wavelet coherence bivariate method. In so doing, we consider two historical market prices (or time series) as x_t and y_t having the wavelet transforms $W_x(\tau,s)$ and $W_y(\tau,s)$, respectively. We then express the Cross-Wavelet Power Spectrum (XWT) of the pair of series as $W^{xy} = W^x W^{y*}$.

Following Torrence and Compo (1998), we define the theoretical distribution of XWT for our pair of series having power spectra P_k^x and P_k^y as:

$$D\left(\frac{\left|W_n^x(s)W_n^{y}*(s)\right|}{\sigma_x\sigma_y} < p\right) = \frac{Z_v(p)}{v}\sqrt{P_k^x P_k^y} \tag{2}$$

where, $z_v(p)$ denotes level confidence associated with the probability value *p*, of the density function defined by square-root of two chi-square (χ^2) distribution products. Also, we define the phase difference, used to examine interdependence or lead (lag) nexuses between pairs of series as:

$$\theta_{\mathbf{x}} = \tan^{-1}\left\{\frac{I(W_t^{\mathbf{x}})}{\Re(W_t^{\mathbf{x}})}\right\}, \qquad \theta_{\mathbf{x}} \in [-\pi, \pi] \tag{3}$$

where, all terms remain as defined. In the wavelet plot, phase vectors are represented by arrows, with arrows pointing right – as in-phase; left – as anti-phase; down – as series *x* leading *y*; and up – as series *x* lagging *y*.

Using the approach of Torrence and Webster (1999), we finally express the wavelet coherence for our pairs of series as:

$$R_t^2(s) = \frac{\left|S\left(S^{-1}W_t^{\mathbf{x}}(s)\right)\right|^2}{S\left(S^{-1}\left|W_t^x(s)\right|^2\right) \bullet S\left(S^{-1}\left|W_t^y(s)\right|^2\right)} \tag{4}$$

where, *s* denotes smoothing operator; and $0 \le R_t^2(s) \le 1$. Grinsted et al (2004) view (4) as similar with traditional correlation measure, but ascribe that the wavelet coherence encompasses such local correlation measure with features of time-frequency space.

A multiple stochastic process, $X_t = (x_{1t}, x_{2t}, \dots, x_{nt})$ is defined where $W_{jt} = (w_{1jt}, w_{2jt}, \dots, w_{njt})$ denotes the scale $\gamma_j\gamma_j$ wavelet coefficients generated through application of the maximal overlap discrete wavelet transform (MODWT) to each $x_{it}x_{it}$ process. The wavelet multiple correlation (WMC) $\varphi_X(\gamma_j)$, is the single set of multi-scale correlations.

For each wavelet scale γ_j, the square root of the regression coefficient of determination is computed in that linear combination of variables w_{1jt}, $j = 1, \dots, n$ for which coefficient of determination is maximum. The coefficient of determination corresponding to the regression of a variable z_i on a set of regressors $\{z_k \; k \neq 1\}$ is obtained as $R^2 = 1 - 1/\rho^{ii}$, where ρ^{ii} is the *ith* diagonal element of the inverse of the correlation matrix P. The WMC $\varphi_X(\gamma_j)$ is computed as:

$$\varphi_x(\gamma_j) = \sqrt{1 - \frac{1}{\max diag\ P_j^{-1}}} \tag{5}$$

where, P_j is the $n \times n$ correlation matrix of W_{jt}, and the *max diag* (.) operator selects the prime element in the diagonal of the argument. During the regression of the z_i on the remaining variables in the system, the R_i^2 coefficient can be shown to be equal to the square of correlation between the observed values of $z_i z_i$ obtained from such regression. WMC $\varphi_X(\gamma_j)$ thus, can also be specified as:

$$\varphi_x(\gamma_j) = Corr(w_{ijt}, \widehat{w_{ijt}}) = \frac{Cov(w_{ijt}, \widehat{w_{ijt}})}{\sqrt{Var(w_{ijt})Var(\hat{w}_{ijt})}} \tag{6}$$

$Var(w_{ijt}) = \bar{\delta}_j^2 = \frac{1}{T_j} \sum_{t=i_j-1}^{T-1} w_{ijt}^2$ -variances given by:

$$Cov(w_{ijt}, \hat{w}_{ijt}) = \hat{\beta}_j = \frac{1}{T_j} \sum_{t=L_j-1}^{T-1} w_{ijt}\hat{w}_{ijt}$$

where, w_{ij} on the set of regressors $(w_{kj}, k \neq 1)$ leads to maximization of the coefficient of determination, $\hat{w}_{ij}$ signifies the matching fitted values. The number of wavelet coefficients affected by the boundary associated with a wavelet filter of length L and scale γ_j is given by $L_j = (2^j - 1)(L - 1) + 1$; then we have $\tilde{T}_j = T - L_j + 1$ as the number of coefficients unaffected by the boundary conditions.

Finally, by allowing a lag τ between observed and fitted values of the variable selected as the criterion at each scale γ_j we may also define the wavelet multiple cross-correlation (WMCC) as:

$$\varphi_x\tau(\gamma_j) = Corr(w_{ijt}, \hat{w}_{ijt+\tau}) = \frac{Cov(w_{ijt}, \hat{w}_{ijt+\tau})}{\sqrt{Var(w_{ijt})\ Var(\hat{w}_{ijt+\tau})}} \tag{7}$$

4. Data and preliminary results

The data for this study can be grouped into three: African stock market indexes, commodity prices, and commodity indexes. The first strand of data consists of stock market indexes sampled based on data availability for the period considered and their relative verve in the continent or their sub-region. The choice of the equity market sample was first, influenced by whether or not a particular country was a major importer or exporter of at least one of the commodities considered in the sample (i.e., gold, oil, cotton, coffee, tea, or cocoa). This allows us to examine how time and frequency impact prices of different commodities. A second consideration for the selection of the sample was the time frame of interest. We choose the time frame of February 1996 to February 2018 (22 years). This time frame is very illustrative as it captures various phases of equity market and commodities booms and bust cycles such as the Asian crisis of 1997-2000, the commodities price booms of 2002-2008, the global financial and Eurozone crisis of 2007-2010, and so on. Based on the above criteria, we selected stock markets of nine African countries: South Africa, Botswana and Ghana primarily export precious metals; Nigeria exports energy (oil); Ivory Coast, Morocco, Egypt, Tunisia, and Kenya export food or agricultural products.

The second strand of data comprises commodity prices and indexes of varied forms. First, we consider prices of main commodities such as diamond, coffee, tea, cocoa, gold, cotton, and crude oil. The commodities are chosen to also reflect their significance in the global economy and to international investors. Moreover, the selected commodities are main export and import products in some of the sampled countries. Third, in a broader sense, and consistent with the IMF's classification system for commodities, we consider four other classes of commodities. These are metals (proxied by the Metals Price Index - MPI), food (proxied by the Beverages Price Index - BPI), agricultural products, and energy – see also Kablan et al (2017). These provide a unique data set that has not seen much application to the African capital markets. The inclusion of commodity indexes is borne out of the renewed interest by fund managers around the world to focus on index trading.

For each equity market, we used the matching commodity price that is either the main or among the main export or import products. That is, we used cocoa, gold, and oil for Ghana; tea and coffee for Kenya; oil for Nigeria, cocoa for Ivory Coast; gold for South Africa; diamond for Botswana; and cotton for Egypt, Tunisia, and Morocco. The sampled African economies are opened to foreign capital flows and thus becoming highly relevant in international investor portfolios. This high market openness to non-resident foreign investors opens doors for higher portfolio flows to the stock markets. The sampled markets reflect the major stocks by market size (volume) in their

respective regional blocks. The primary activities on most of these stock markets are the issuance of bonds and equities with predominantly online and intraday trading mechanisms. The exceptional market is the South African Johannesburg Stock Exchange (JSE) that issues bonds, equities, and derivatives with online, margin, and intraday trading mechanisms.

All data are of monthly periodicity and expressed in US dollars (US$). The data are analysed in their returns expressed as the log differential between two consecutive prices or indexes. The equity market data are gleaned from Bloomberg, while commodities prices and indexes are obtained from the IMF website. We assume that hedging and/or diversification opportunities are viewed from the perspective of international investors.

Figures 1a and 1b depict the time trend of standardized prices of commodities and equity prices (subtracting the price at time *t* from the series mean and dividing by standard deviations). As shown in Figure 1a, after some busts and booms from 1996, commodity prices rebounded after 2000. Between 2008 and 2011, a wide range of commodities including agriculture, energy, and metals rose and fell together. Commodities prices may exhibit such tendencies of "all-rising" and "all-falling" if they are related as either complements or substitutes in production or consumption (Pradhananga, 2016). Commodities showing such price developments may transmit idiosyncratic demand or supply shocks to one another and or other assets such as stocks. Despite this, commodity-specific shocks may not adequately explain broad co-movements across unrelated commodities or across other asset classes (Pradhananga, 2016). Rather, three strands of literature explain such price shocks transmissions across unrelated commodities and other assets. Some analysts (for example, Krugman, 2008; Hamilton, 2009; Kilian, 2009) ascribe this to rises in demand and supply.[3] That said, Jacks and Stuermer (2020) establish that commodity demand shocks strongly dominate commodity supply shocks in driving prices over a broad set of assets and over a broad period of time. The second strand of literature argues from the stand point of financialization of commodities[4] (Mayer, 2009; Robles et al, 2009) which leads to large flow of investments into commodity markets, driven largely by the fundamentals of financial markets. The third strand of the literature explains the dynamics of drastic different price tendencies on account of devaluation of the USD (Akram, 2008).

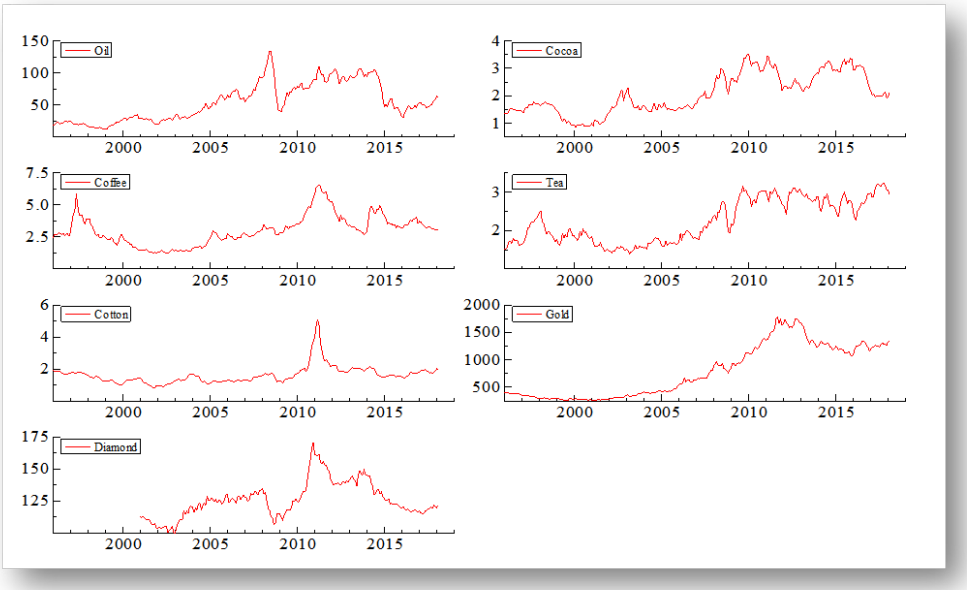
Table 1: Commodity and equity markets shocks origins and their main events

	Events	Year	Commodity shock origin
Commodities			
Oil	2nd oil crisis	1979-1980	Aggregate supply side
	Iraqi invasion of Kuwait	1990	Aggregate supply side
	Housing market boom	2000	Aggregate demand side
	9/11 attacks	2001	Precautionary demand
	PdVSA workers' strike	2002	Supply side
	2nd war in Iraq	2003	Precautionary demand
	Emerging markets growth	2006-2007	Aggregate demand side
	Global financial crisis	2008	Aggregate demand side
	European sovereign debt	2010	Aggregate demand side
Beverage	Effects of oil shocks, reduced interest rates	1979-1980	Aggregate demand side
	Decrease in beverage index	1980-2000	Deterioration of terms of trade
	Food price shock	2007-2008	Aggregate demand side
	Global financial crisis	2008	Aggregate demand side
	European sovereign debt	2010	Aggregate demand side
Agricultural raw material	Effects of oil shock, declined interest rates	1979-1980	Aggregate demand side
	Reduction in agricultural raw material index	1980-2000	Deterioration of terms of trade
	Commodity price boom	2005-2008	Aggregate demand side
	Emerging market growth	2006-2007	Aggregate demand side
	Global financial crisis	2008	Aggregate demand side
	European sovereign debt	2010	Aggregate demand side
Metals	Effects of oil shock, decreased interest rates	1979-1980	Aggregate demand side
	Decrease in metal index	1980-2000	Deterioration of terms of trade
	Emerging markets growth	2006-2007	Aggregate demand side
	Global financial crisis	2008	Aggregate demand side

	European sovereign debt		
	End of the boom in 1969		
	Compounded by Energy crisis		
Equity Markets	Latin American debt crisis		
Brazilian markets crash	Iraq invaded Kuwait Causing oil prices to increase	2010	Aggregate demand side
	Investors deserted emerging Asian shares	1971	Energy crisis drive
Early 1990s crisis	Global stock market crash that was caused by an economic crisis in Asia.	1970s 1980s	Energy crisis drive Energy crisis drive
Asian financial crisis		1990	Oil price shocks Oil price shocks
	Collapse of a technology bubble.	1997 1997	Equity markets idiosyncratic shocks Equity markets idiosyncratic shocks
Dot-com bubble	The Shanghai Stock Exchange tumbles 9% from unexpected selloffs triggering the Dow Jones Industrial Average, Nasdaq Composite and SandP 500 all experienced declines of greater than 20% from their peaks major drops in worldwide stock markets.	2000	Technology driven
Global financial crisis		Feb. 2007	Global credit crunch
		Jun. 2009	Equity market idiosyncratic shocks
		2007-2008	Global credit crunch
European sovereign debt crisis	US subprime and credit default swap shocks	2010	Sovereign credit risks
	Sovereign credit downgrade of Greece	2015-2016	Equity market idiosyncratic shocks
Chinese stock market crash	China stock market crash starts in June and continues into July and August		

Source: Kablan et al (2017) and authors' compilations.

Figure 1a: Standardized time trends of commodities



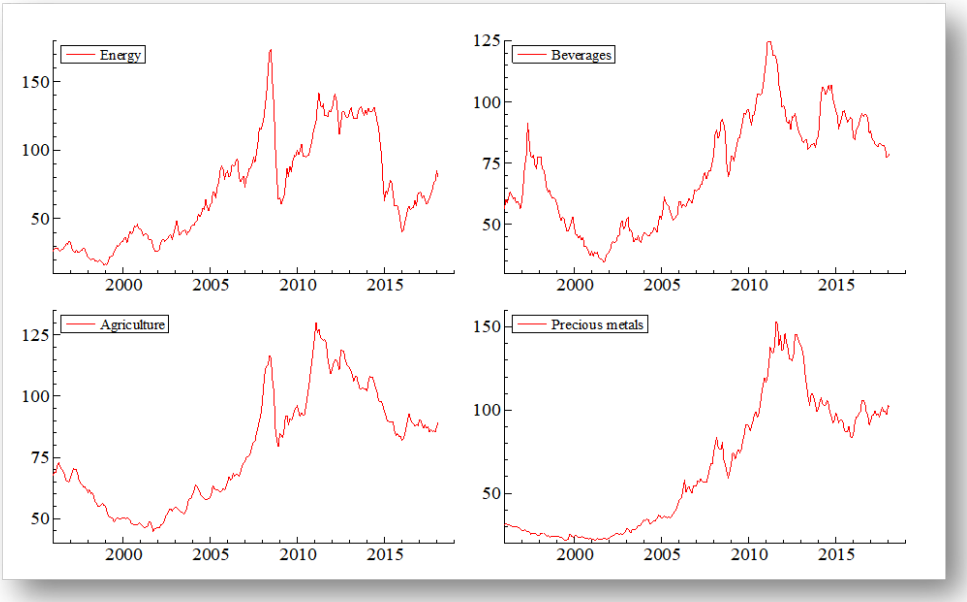
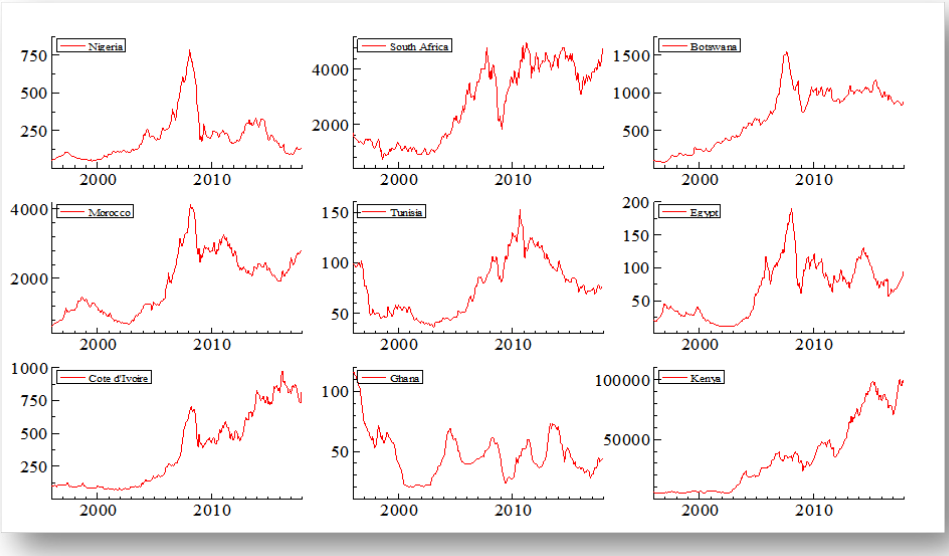


Figure 1b: Standardized time trends of African stock markets



In Figure 1b, varied patterns of volatility hikes are observed across the equity markets with some of the price developments similar to what is identified in the commodities. This can be ascribed to the influence of various crises during the sample period. As can be observed from Table 1, some of the shocks in equity markets originate from commodity shocks.

Table 2 depicts descriptive statistics for the monthly returns of the entire series. Generally, all the series have very low monthly average returns. For unconditional standard deviation, diamond appears to have the higher risk, albeit small. All the series have fat-tail behaviour and non-normally distributed. But for South Africa, agriculture, energy, oil, and diamond, all other series are positively skewed.

Table 2: Descriptive statistics

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Observations
Botswana	0.01	0.06	1.74	15.39	1828.59	265
Cote d'Ivoire	0.01	0.07	0.38	4.41	28.19	265
Ghana	-0.00	0.07	0.72	5.57	96.01	265
Kenya	0.01	0.07	0.24	4.91	43.09	265
Nigeria	0.01	0.09	0.27	7.43	220.11	265
Tunisia	0.00	0.05	0.10	5.51	69.83	265
Egypt	0.01	0.09	0.00	5.03	45.14	263
Morocco	0.01	0.05	0.22	4.34	21.82	263
South Africa	0.01	0.07	-0.59	4.74	48.63	263
Agriculture	0.00	0.03	-0.44	6.89	176.06	265
Beverages	0.00	0.04	0.36	4.67	36.76	265
Cocoa	0.00	0.06	0.19	4.20	17.69	265
Coffee	0.00	0.07	1.04	5.74	131.32	265

Cotton	0.00	0.06	0.21	5.91	95.28	265
Energy	0.01	0.07	-0.44	3.43	10.44	265
Gold	0.01	0.04	0.49	4.53	36.68	265
Oil	0.01	0.08	-0.36	3.59	9.62	265
Precious Metals	0.01	0.04	0.19	3.77	8.23	265
Tea	0.00	0.05	0.33	3.62	8.88	265
Diamond	-0.15	0.22	-0.14	6.00	53.2	193

Note: Jacque-Bera statistics are all significant at 1%.

Analysis of co-movement with wavelets

Prior to examining markets interconnectedness using wavelets, we first employ the pair-wise correlation analysis to examine the linear relationship among the commodities and stock returns.[5] The results show positive relationship between Nigeria stock returns and all commodities (oil, cocoa, coffee, tea, cotton, gold, diamond, energy, beverages, agriculture and precious metals), albeit weak. In Botswana, diamond, cocoa and cotton prices were found to have a weak negative correlation with stock returns, whereas all other commodities showed weak positive relationship. Cocoa and diamond prices showed negative relationship with Tunisia's stock returns over the sample. Oil, coffee, tea, cotton, gold, energy, beverages, agriculture and precious metals showed positive correlation with Tunisia's stock returns, however the relationships were weak. Similar to Nigeria, stock returns in Cote d'Ivoire were positively correlated to commodity prices, except diamond. But in all cases, the correlation was found to be weak. In the case of Ghana, except for prices of diamond, coffee, tea and beverages, all other commodities were found to have positive correlation with stock returns. In both cases, the relationship was weak. Cocoa, coffee, gold and precious metals were found to have weak negative correlation with Kenya stock returns. Subsequently, oil, tea, cotton, energy, beverages and agriculture showed weak positive correlation with Kenya stock returns.

Overall, we observe that the relationship between commodities and African stock returns are both negative and positive, albeit weak. While this dynamics may reflect individual economic fundamentals, it is supported by theory and empirical literature. Evidence of significant positive co-movement between commodities and stocks could be attributed to financialization without fundamentals, and this could happen in different ways.[6] First, prices of commodities are likely to co-jump if commodity futures are traded based on herd-behaviour or other portfolio considerations but not based on commodity-specific demand and supply fundamentals. The herd-behaviour could align equity prices with the overall market (Chang et al, 2000). Thus, as market participants subdue their own beliefs and make investment choices that are driven by market sentiments, the correlated behaviour of traders may cause portfolio returns to show higher co-movements, resulting in lower deviations within the cross assets portfolio (Demirer et al, 2015). This is practically the case for financial traders who take

long and short positions in commodity-equity derivatives markets not individually but as passive index traders, as was the case in 2008. Second, increased correlation among related and unrelated assets could also happen on account of liquidity effects when speculators in the commodity markets trade in two or more equity markets. Third, if one equity market has higher weightings in aggregate commodities indexes, shocks (supply or speculative bubbles) in that commodity might transmit to others, even if there are no changes in the fundamentals of those specific commodities.

Both positive and negative correlations between stocks and commodities may lend to higher opportunities for diversification across the two markets. While the possibility for diversification arising from negative correlations is obvious, that for positive correlations is a bit tricky. However, as established by Baur and Lucey (2010), a diversifier shows positive although not perfect correlation with another asset or portfolio on average. With this, increased correlations may imply commodities/stocks can present better diversification or hedging avenues on account that the correlations rise in absolute terms (Olson et al, 2014). Using empirical evidence to support this, Boako and Alagidede (2016) argued that since hedging entails taking a long position in one asset (as in stocks) and a short position in another (say commodities), an increase in correlations means that a price fall in the commodities future/spot market could be offset by a long position in the stocks, thereby making the hedge effective.

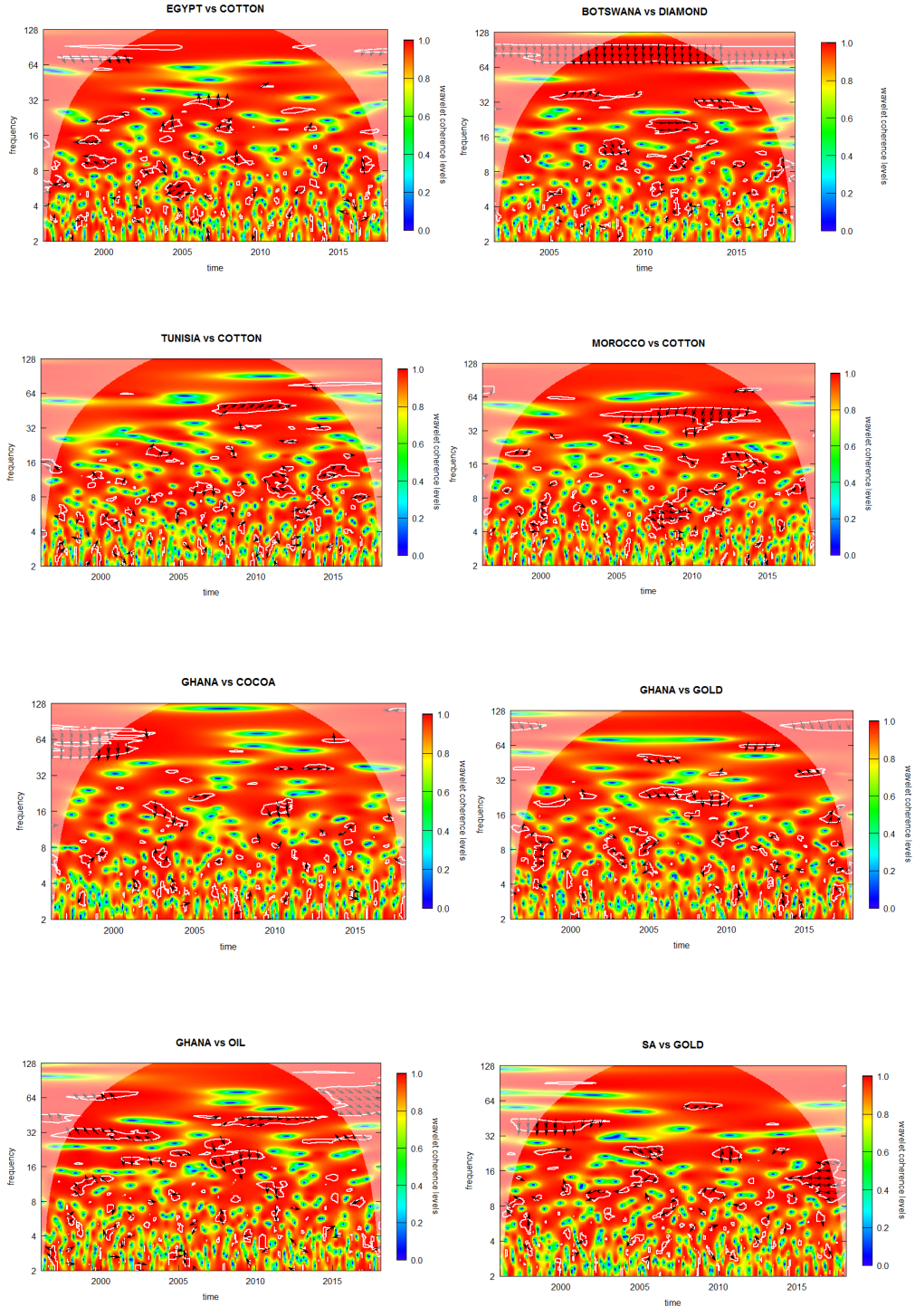
Further to the correlations analysis, we estimate wavelet coherence to analyse time-varying correlation and derive all information about structural changes in the data through a phase difference technique (Aguiar-Conraria and Soares, 2011). Figure 2 presents results of coherence (in contour plots) and phase difference arrows between the equity market returns and commodities. Vertical axis depicts monthly frequency ranges from lower (two months) to upper (128 months), while the horizontal axis show time. The region indicating 95% confidence interval simulated using Monte Carlo method of two white noise series with Bartlett window type is indicated in white contour lines in the cone. Again, colour codes on the right-side vertical bar depict local correlations (coherence) ranging from red (high coherence) to blue (low coherence). Thus, red colour inside the white contour at the bottom (top) of the plots represents strong co-movement at low (high) frequencies, whilst red colour in the white contours at the left-hand (right-hand) side symbolizes strong co-movement at the beginning (end) of the sample period.

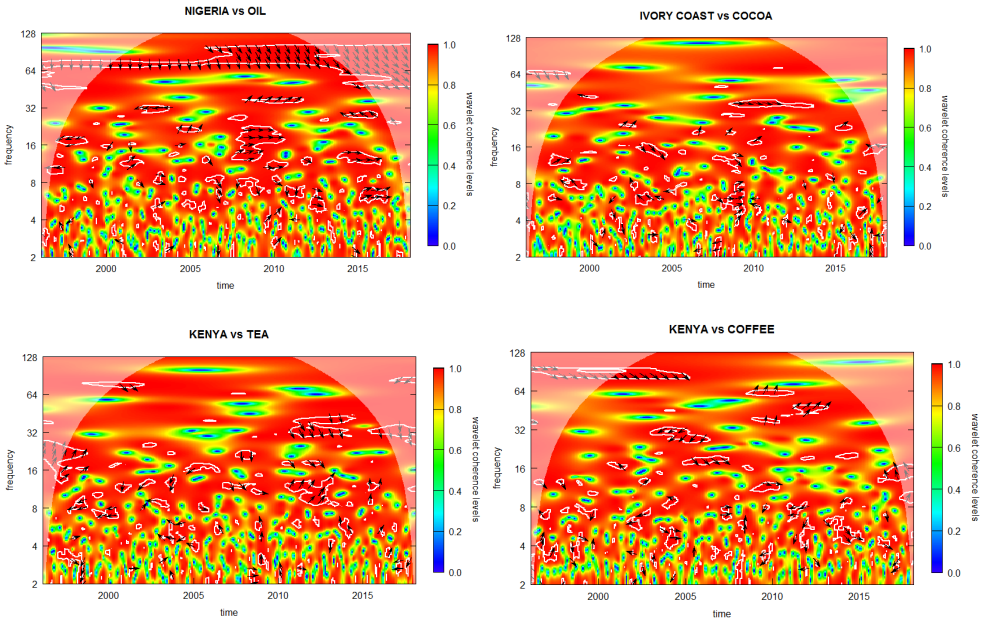
Phase difference arrows pointing to the right show that the series are in a synchronized phase with cyclical interaction between the series but when they are to the left suggest that the two series are out of phase and have anti-cyclical effect. When they are pointing right and up (down) it means the stock market is lagging (leading). Arrows to the left and up (down) suggest the stock market is leading (lagging). We present results and discussion of the wavelet squared coherency and phase differences below.

First, in Figure 2a, we show how each stock market is interlinked with the dominant imported or exported commodity (ies) in the respective economies. At first glance, we observe commonly high coherences across market pairs. Majority of the noticeable

coherences covering longer periods, however, are observed at intermediate-to-high frequencies. Also, the coherency is generally periodic and episodic.

Figure 2a: Cross-wavelet coherence between equity and individual commodity returns





It is informative to note that some of the coherencies fall outside the region of edge effects (cone of influence) and are therefore not significant. The phase difference arrows show non-homogenous linkages among markets across time because arrow vectors point left and right, and up and down regularly.

For Botswana, we observed a highly integrated phase synchronized relationship between returns of the Botswana Gaborone Index and that of diamond at higher frequencies within the band of 65-95 between 2005 and 2015. Strangely, despite the fact that the Botswana economy has for many years been driven by mineral-led growth and remains dominated by the mining sector, particularly diamond, we do not observe greater diamond-led relationship between the Botswana stock market and diamond prices post-2015. This perhaps is a wake-up call that the end of the diamond-led growth is within sight. It might perhaps be indicative of an economy that is aggressively pursuing economic diversification. In the year 2017, while affirming Botswana's Sovereign Credit Rating of A2, with a stable outlook, Moody's Investors Service cited "progress with diamond beneficiation and economic diversification, combined with efficiency enhancing public sector reforms as factors that could exert positive pressure on the rating over the medium term".

The connection between the stock markets of Egypt, Morocco, and Tunisia to cotton prices is a bit sparse across time and frequency. Notable, however, is the linkage with the Casablanca exchange of Morocco within the frequency band 32-50 from 2005 to 2015. The result is expected because, although these economies have either huge imports or exports of cotton, the weighting compositions of firms that make up the equity markets are not predominantly in the cotton industry. For Ghana, significant but isolated relationships between the stock market returns and gold, oil,

and cocoa are found. These non-homogenous interlinkages are observed largely around intermediate and lower scales (high frequencies). Although, cocoa and gold have been the two main export commodities and economic mainstays of the Ghanaian economy, oil price shocks seem to have higher connectedness with the stock market, leading the stock market in the pre-2010 periods. Another observation for Ghana is that the coherences with gold and cocoa become more remote after 2010 where the country started oil production in commercial quantities. This finding is similar to the observation by Boako et al (2015) that the relationship of the Ghana equity market returns with cocoa and gold in the pre-oil production period was higher than the post-oil production.

The relationship between crude oil price shocks and the Nigeria stock market is prominently shown, particularly at the long-run fluctuation band of 64-100 from late 2005 to early 2015. At this band, the Nigeria stock market leads but the linkages in the intermediate spectra after 2008 appear to be just in a synchronized phase. The relatively higher connectedness between the Nigeria bourse and crude oil price is telling of the controlling effects of oil price shocks on the Nigerian economy. As established by Effiong (2014), the Nigerian stock market's response to oil supply shocks is insignificantly negative but significantly positive to aggregate demand and oil‐specific demand shocks. And that, the cumulative effects of the oil price shocks account for about 47% of the variation in stock prices in the long term.

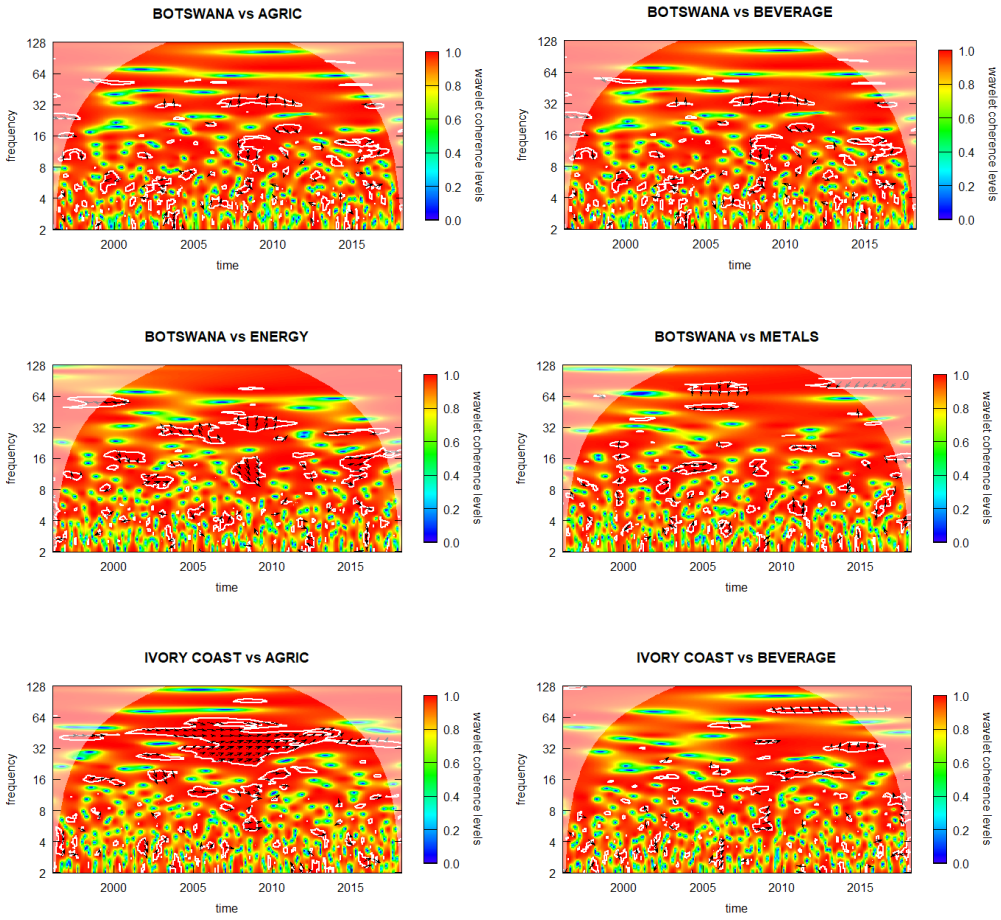
For South Africa, the influence of gold on the Johannesburg Stock Exchange is seen across the entire spectrum of the data sample, albeit episodic. At the frequency band of 32-35, we observed significant linkages from late 2008 to 2010. Another quite noticeable block of interconnection can be observed from 2015 to 2016 within the frequency band of 8-18. Although Ivory Coast is high in the production of cocoa (world leader) its regional bourse does not show much connectedness with price dynamics in the cocoa market. For Kenya, both coffee and tea (major export products) have segmented significant correlations with returns on the Nairobi Stock Exchange.

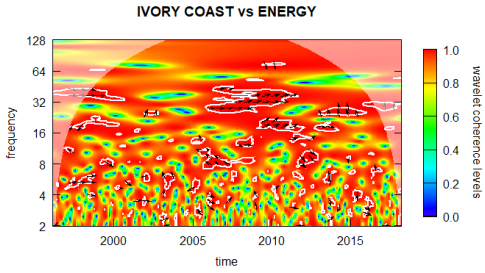
Overall, it is observed that the equity markets in African economies show semblances of periodic coherences with commodities, with the coherences largely narrowed to medium-short-run fluctuations (higher frequencies). The long-term linkages, however, appear more noticeable than short-intermediate coherences, positing that persistent shocks have a greater influence on prices than transitory fluctuations. It is also observed that the financial crisis of 2007-2009 (GFC) and the European sovereign debt crisis did not change the connectedness in the two markets. The presence of lead-lag effects and stronger co-movements at short-run fluctuations may induce arbitrage and diversification opportunities to both local and international investors with long-term investment horizons. Thus, portfolio investors seeking to diversify across African stock markets may have to consider long-term investors than short-term ones since diversification avenues could potentially be beneficial for the former than the latter.

Similar to the above, we examine how the equity markets on average interconnect with aggregate commodities indexes – agriculture, energy, beverage, and metals. We

observe, across the graphs, the presence of higher correlations among markets that are time-variant and broadly within the intermediate to long-run periods. Specifically, we observe high coherence for the equity markets and agricultural raw materials. The long-, medium-, and short-term coherence levels from 2005 to 2012 were unevenly similar. The coherence for Ivory Coast and agriculture raw materials however seem elongated, oscillating within the band of 20-64 with a coherence index of averagely 0.8-0.9. Small patches of coherence also abound in the pre-2005 and post-2010 periods across the scales. In all, the instances of long-run coherence are greatly observed than short-run coherence. This result suggests that the equity markets are less influenced by transitory fluctuations (i.e., short-term changes) than persistent shocks (medium- and long-term changes) to agricultural commodity prices. Aside agriculture, stronger long-run coherences are also noticed with energy and beverages. Coherence with metals is, however, minuscule and virtually absent for some pairs.

Figure 2b: Cross-wavelet coherence between equity and aggregate commodity returns




IVORY COAST vs ENERGY
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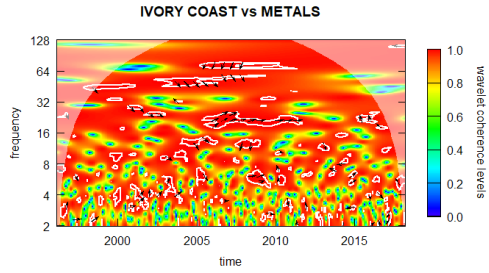
IVORY COAST vs METALS
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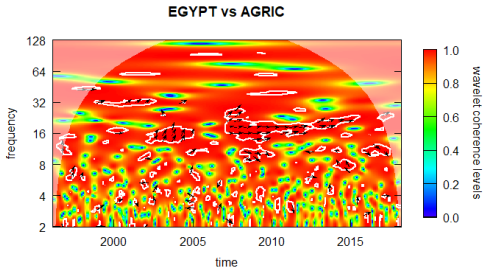
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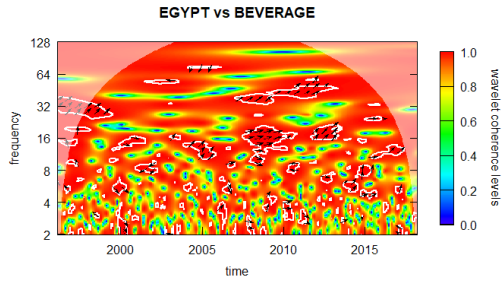
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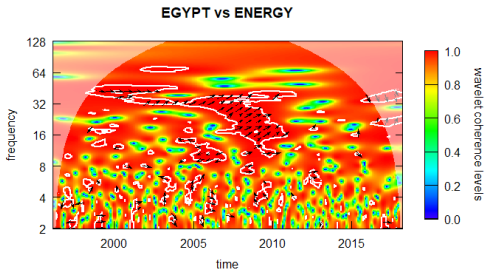
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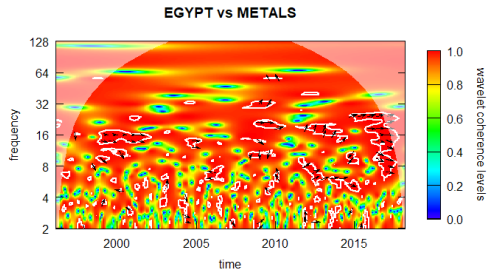
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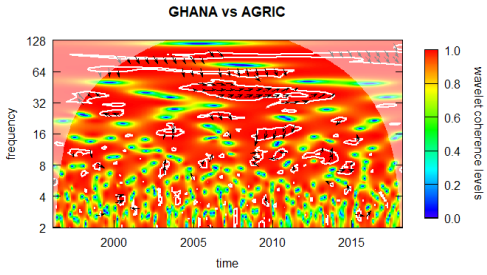
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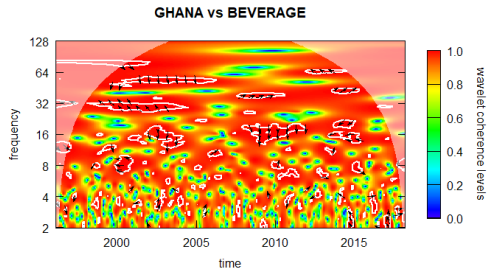
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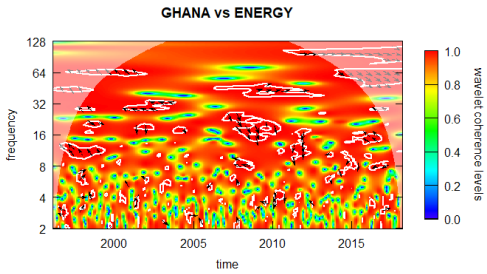
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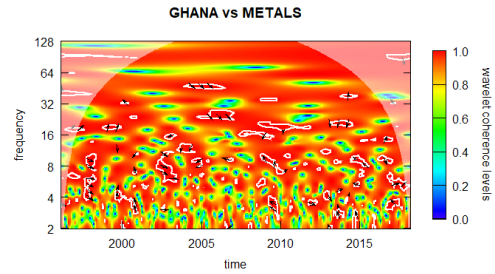
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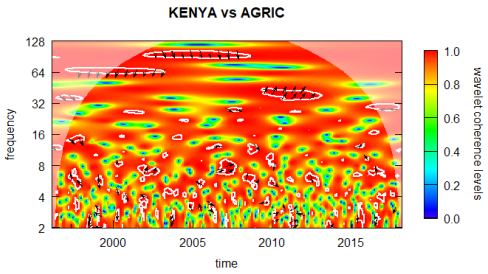
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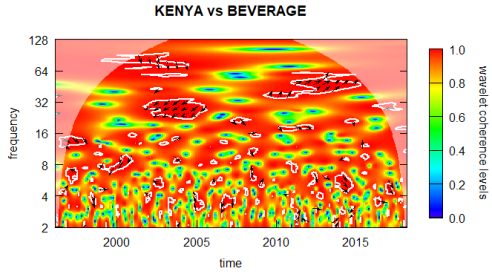
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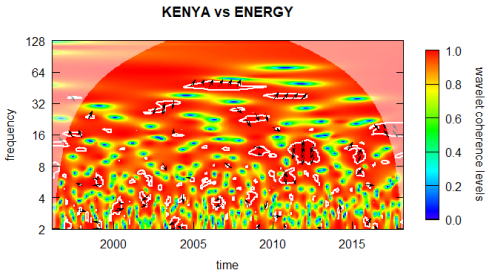
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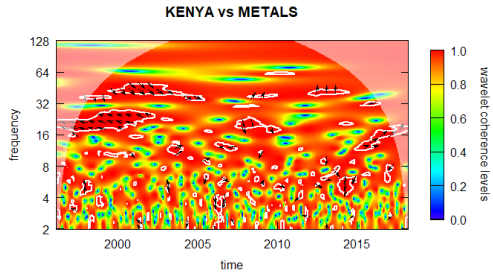
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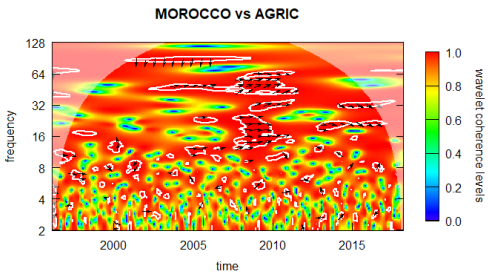
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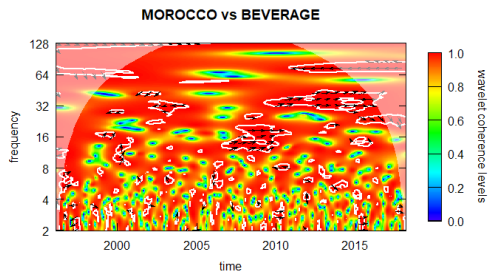
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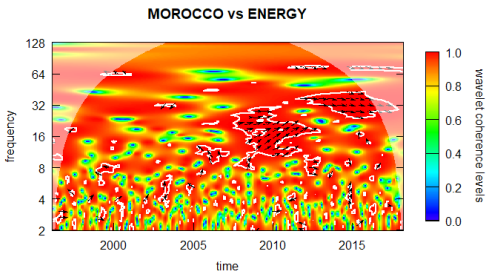
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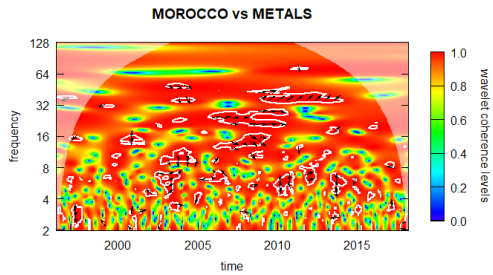
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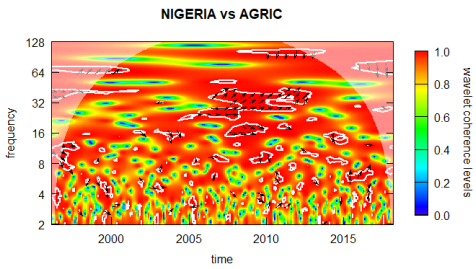
NIGERIA vs AGRIC
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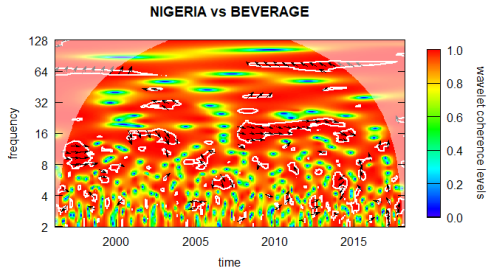
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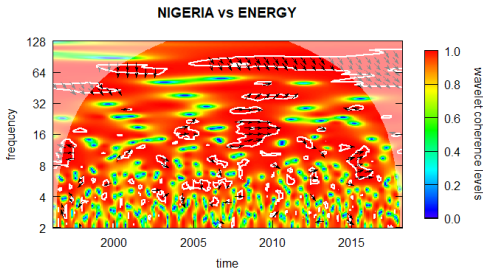
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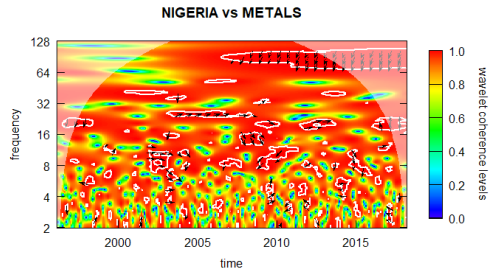
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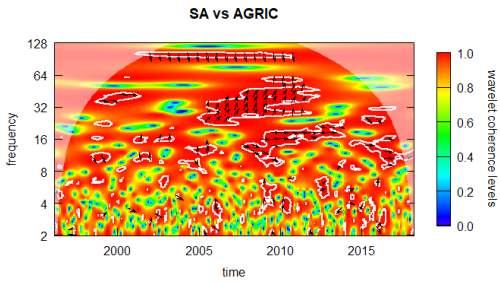
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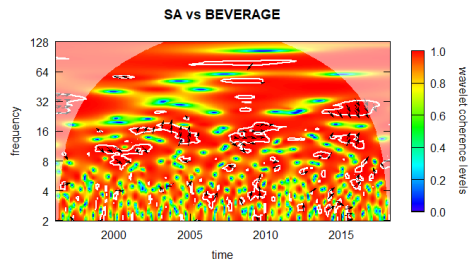
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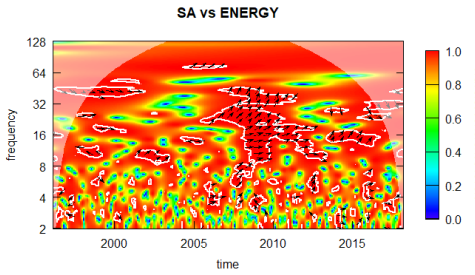
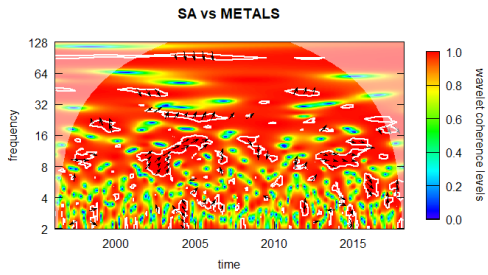
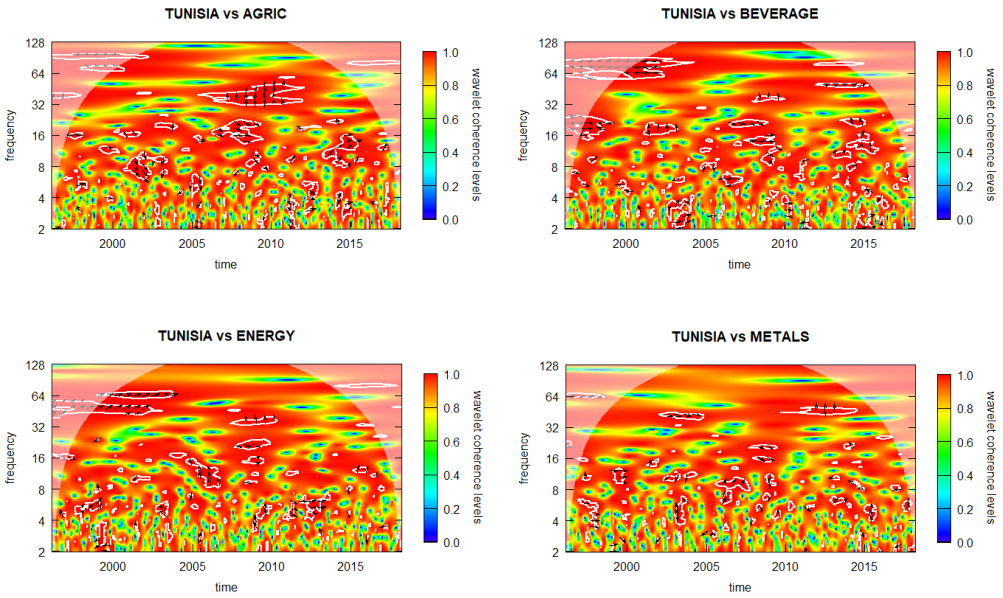
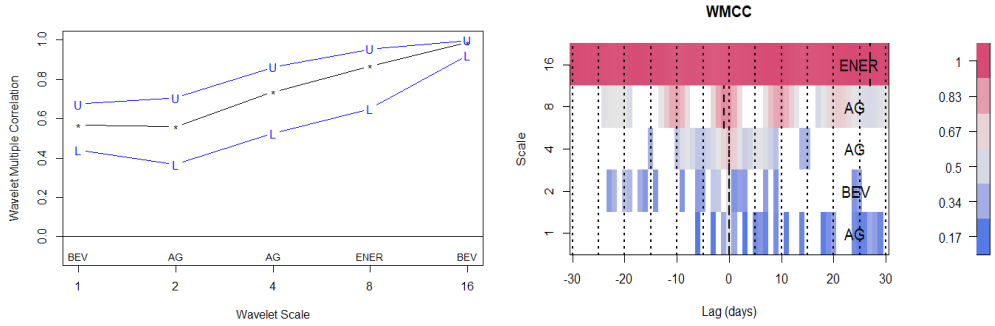

SA vs ENERGY
frequency
128
64
32
16
8
4
2
2000
2005
2010
2015
time
wavelet coherence levels
1.0
0.8
0.6
0.4
0.2
0.0


SA vs METALS
frequency
128
64
32
16
8
4
2
2000
2005
2010
2015
time
wavelet coherence levels
1.0
0.8
0.6
0.4
0.2
0.0

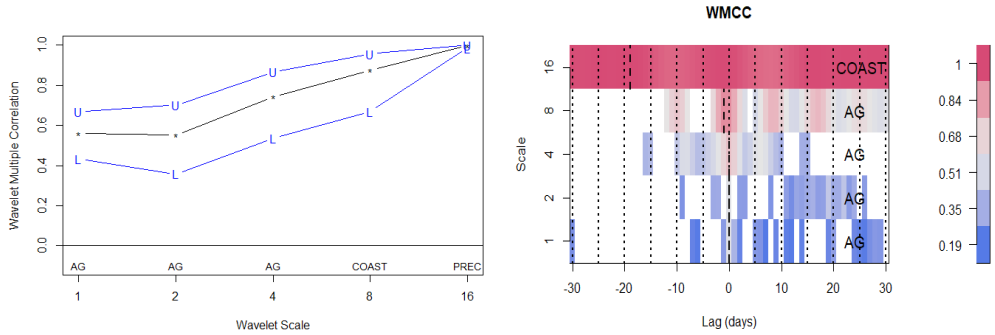


Next, we examine patterns of wavelet multiple correlation within 95% confidence intervals[7] obtained from all stock market series and aggregate commodities to determine the level of integration for the linear combination of the series. This is shown in Figure 3. The left panel plots indicate stronger correlations at all the frequencies that grow with lower frequencies. The correlations basically start at 0.4 and grow to almost 1 at the longest time scale. However, beyond this the multiple correlations appear insignificant. The heat map at the right-hand side show the Wavelet Multiple Cross-Correlation (WMCC) for the different wavelet scales with lead/lag relationships. The series that maximizes the multiple correlations against the linear combination of other markets is shown in the upper right corner. We find that multiple cross-correlations get stronger at shorter scales (longer frequencies). Of all the nine stock markets, it is only the Ivory Coast regional bourse that maximizes the multiple correlations against the linear combinations of the aggregate commodity indexes. This is indicative that Ivory Coast has the potential to lead or lag the commodities markets along the frequencies. However, given that the Ivorian stock exchange is more like a regional exchange than a country-specific one, it is difficult to suggest that only the economic factors in Ivory Coast alone are enough to explain this dynamics.

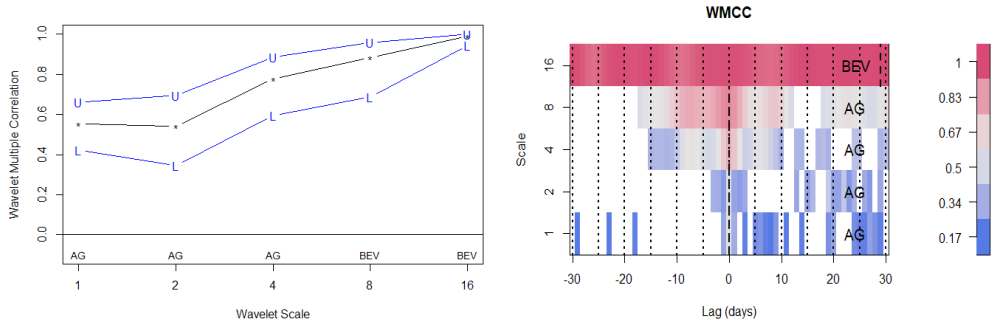
Figure 3: Wavelet multiple cross-correlation for African stock markets and commodities indexes at different time scales



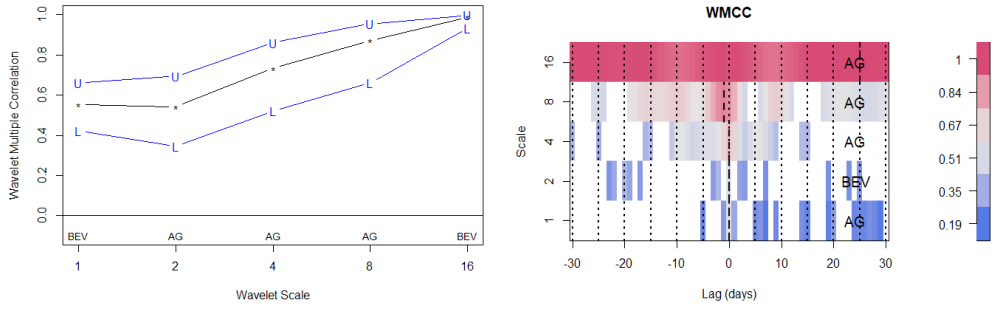
a: Botswana vs. Commodity Indexes



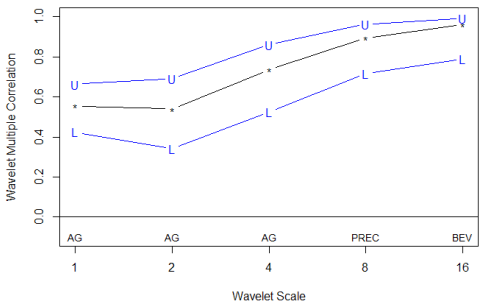
b: Ivory Coast vs. Commodity Indexes

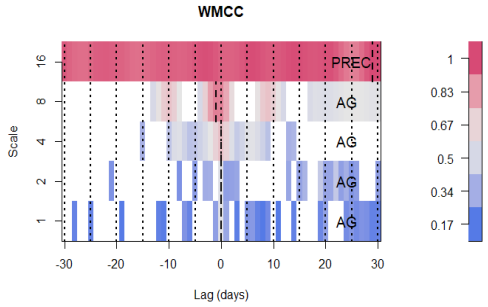


c: Egypt vs. Commodity Indexes

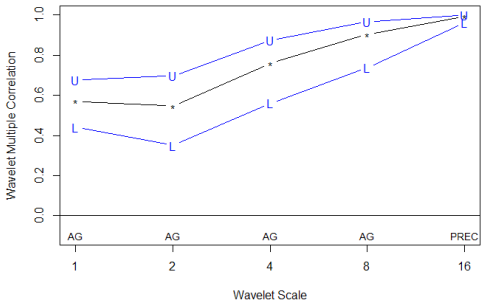


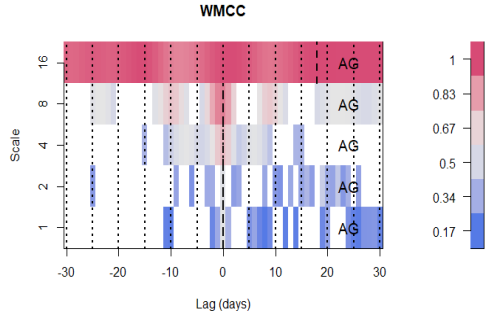
d: Ghana vs. Commodity Indexes



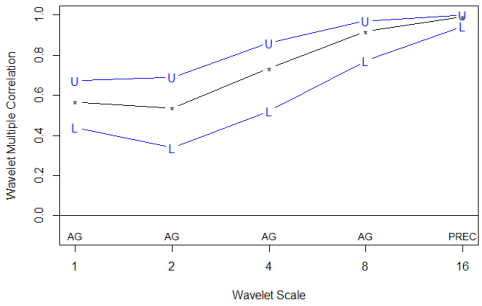


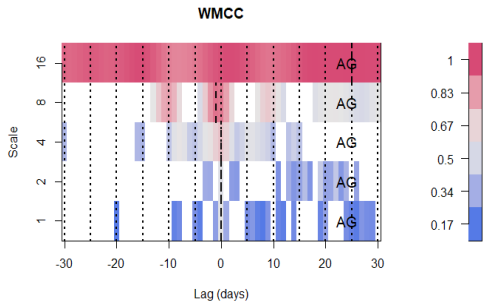
e: Kenya vs. Commodity Indexes



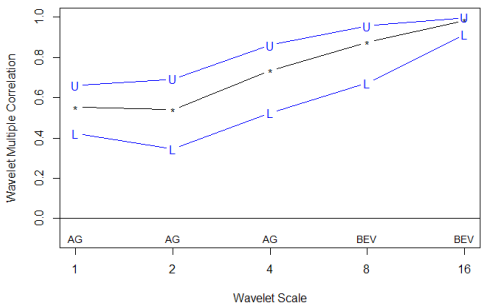


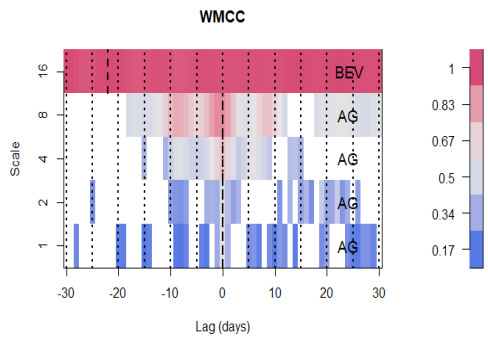
f: Morocco vs. Commodity Indexes



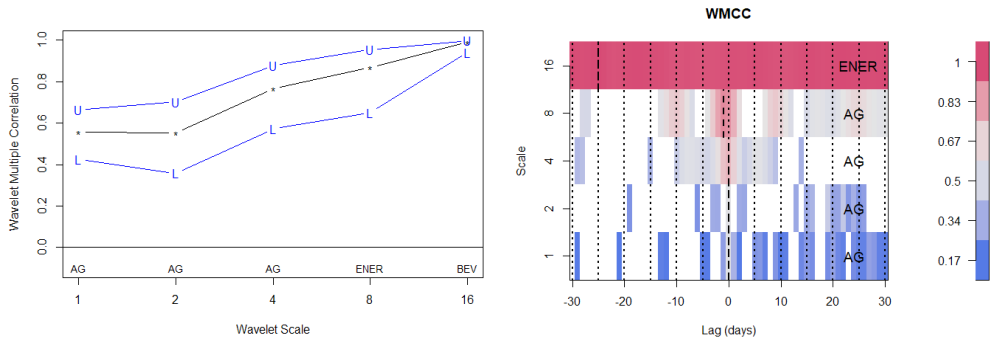


g: Nigeria vs. Commodity Indexes





h: South Africa vs. Commodity Indexes



i: Tunisia vs. Commodity Indexes

Note: The coloured lines correspond to the upper and lower bounds for the 95% confidence interval.

Scale-dependent portfolio risk-adjusted performance analysis

In this section, we present analysis of portfolio risk-adjusted performance of African stock markets with commodities, as well as diversified portfolios that are made up of equities and commodities. For the risk-adjusted performance, we use both the Sharpe ratio (SR) and the Generalized Sharpe ratio (GSR). The Sharpe ratio measures the standard portfolio performance given that the returns of the underlying assets violate the non-normality assumptions of financial assets. The assumption here is that investors are interested in higher moments (that is mean and variance) of their investments – see, for example, Harvey and Siddique (2000). However, if assets have non-normal returns distribution, using the SR to measure risk-adjusted performance can be misleading. For this reason, we apply the GSR in assessing the profitability performance of the African equity markets and commodities – see also, Bekiros et al (2016). The advantage of the GSR over the SR is that the former factors investors' preference for higher moments trading and their expected utility towards optimal capital allocation. Similar to Bekiros et al (2016), although the use of GSR overcomes the shortfalls in the application of the SR, we analyse portfolio performance and compare the two results from the two measures with respect to the decomposed series derived from the wavelet approach for both equities and commodities markets.

We analyse three different portfolio scenarios:

a. A two-asset 'naïve' portfolio with equal weights denoted as *Pf1*. This portfolio is made up of both equity and commodities assets.
b. A two-asset risk-minimizing, yet without reducing expected returns commodity-equity portfolio subject to a no-shorting constraint. This portfolio is denoted as *Pf2*. Akin to Kroner and Ng (1998), the optimal holding weight (w) of equity in a

$1 portfolio of commodity-equity at time *t* is computed as:

$$w^{c} = \frac{\delta_{e}^{2} - \delta^{ce}}{\delta_{c}^{2} - 2\delta^{ce} + \delta_{e}^{2}}$$

where, $\delta_{c}^{2}, \delta_{e}^{2}$, and δ^{ce} are the variance of commodity futures return, the variance of equity index, and the covariance between these return series, respectively. By assuming a mean-variance (MV) utility function in the absence of short-selling, the following constraint is imposed on the optimal weight of the stocks through optimization:

$$w_{t}^{oil,s} = \begin{cases} 0, & f \quad w_{t}^{oil,s} < 0 \\ w_{t}^{oil,s}, & f \quad 0 \le w_{t}^{oil,s} \le 1 \\ 1, & f \quad w_{t}^{oil,s} > 1 \end{cases}$$

where, $\left(1 - w_{t}^{oil,s}\right)$ accentuates the dollar investments that the investor makes in the crude oil market at time *t*. The optimal weights of Africa's equities in a commodity-equity portfolio effectively emphasize how much of a $1 portfolio that must be invested in Africa stocks to be able to minimize risk and at the same time maximize returns.

c. A two-asset hedged portfolio (*Pf3*) that minimizes the portfolio's risk by hedging a long position of $1 in the stock market by a short position of β in the commodity futures market. Thus, β becomes the optimal hedge ratio, computed as:

$$\beta = \frac{\delta^{ce}}{\delta_{e}^{2}}$$

With this, we compute the effectiveness and volatility of the hedge to determine whether or not the hedge enhances the portfolio's risk-adjusted performance or presents additional risk. Generally, an accurate conditional volatility should be able to offer superior hedge effectiveness (γ^{*}) (Ku et al, 2007). We compute γ^{*} as the variance reduction for a hedged portfolio (commodities) compared with an unhedged portfolio (equities) as: $\gamma^{*} = \left[1 - \left(\frac{\delta_{e}^{2}}{\delta_{c}^{2}}\right)\right] * 100$

By way of improving on the standard procedure in the empirical literature, we do not just draw on the raw-aggregate series but the wavelet decomposed series with respect to each scale component – see, for example, Bekiros et al (2016). We decompose the series into six high-frequency (short-run periodicity) components as D1, D2, D3, D4, D5, and D6; and one low-frequency part, representing the long-run periodicity (S6). The wavelet filter coefficients and their synthesized series correspond 2-4, 4-8, 8-16, 16-32, 32-64, 64-128 months in the time-domain, while the S6 component captures the long-run trend or near-zero frequency content of the original series. The return and risk (variance) of portfolios *Pf1, Pf2, and Pf3* are determined based

on the weights and time-scale returns and variances of the individual commodities and equities indexes/prices. On account of the episodic price or index fluctuations observed across the series, we endogenously disaggregate the data into various sub-periods as: 1996-2018 (full sample), 1996-2000, 2001-2006, 2007-2009, and 2010-2018.

We use the Sharpe ratio (SR) as the standardized measure of portfolio risk-return trade-off by scaling the expected return by its risk (standard deviation). Bernardo and Ledoit (2000) however criticize the SR on account of its reliance on the normality assumption of financial assets. The Generalized Sharpe ratio (GSR), on the other hand as introduced by Hodges (1998), accounts for the impact of a skewed distribution in risk-return assessments. The GSR is used by investors with different skewness preferences allowing for the different ranking of the same set of risky assets. The GSR is computed as: $SR\sqrt{1 + b(skew/3)SR}$. Thus, GSR depends on the value of the SR, the constant absolute risk aversion (CARA) utility coefficient (*b=1*) and on the value of skewness (skew). A higher SR means a higher adjustment-for-skewness of the return distribution. For a rather low SR, the adjustment-for-skewness in the GSR becomes insignificant. For robustness, the SRs are estimated for all the different sub-samples.

Table 3 records the SR and GSR results for all series and all undiversified portfolios across five sub-periods, namely 1996-2018, 1996-2000, 2001-2006, 2007-2010, and 2011-2018. In the case of the individual undiversified commodity or stock portfolios, the best performing portfolios in the short run (that is from D1-D6) are: a) For both 1996-2018 (the full sample) and 1996-2000 periods, the Nigeria stock market outperforms all the other portfolios, b) Botswana, Ghana, Kenya, energy, agriculture, and precious metals in 2001-2006, c) Nigeria, Botswana, and Cote d'Ivoire for the 2007-2010 period at the lowest scales (highest frequency), and d) Nigeria, Cote d'Ivoire, Kenya, South Africa, and Morocco for the 2011-2018 period. On average, the results for SR are consistent with those of the GSR.

In the medium scales 8-16 months, the results based on the SR and GSR reveal that Nigeria, Botswana and coffee for the period 1996-2000 outperform all other asset portfolios. For the 2001-2006, Botswana, cocoa, gold, and beverages denote the best investments compared to all other assets. Tunisia, Cote d'Ivoire, South Africa, oil, energy and agriculture give the best performances for 2007-2010. And finally, for 2011-2018 the best performing assets are coffee and tea.

In the Appendix[8], we show the frequency-based SR and GSR for the three different dimensions of portfolios: equally weighted (PF1), optimally weighted (PF2), and risk-minimizing portfolios (PF3) over the different sub-periods. In addition, we show the hedge effectiveness (γ^*), as well as the volatility of the equally weighted portfolios (δ). Similar to Bekiros et al (2016), the results indicate that performances of time-scale risk-adjusted returns of diversified portfolios differ across time and frequency. Generally, diversification across paired asset classes is non-effective with low volatilities. Again, the evidence confirms that having a combined portfolio of commodities and equities improves performance for different investment horizons. Specifically, we observe that in non-crisis periods 2001-2006 (Panel C and 2011-2017) it is either the equally weighted or optimally weighted portfolios that show the greatest performances.

However, as we enter into crisis zones such as the Asian crisis of 1997-2000 (Panel B: 1996-2000) and the global financial crisis and Eurozone debt crisis periods (Panel D: 2007-2010), the risk-aversion behaviour of investors become prominent as the risk-minimizing portfolios record the highest performances. This finding is similar to Bekiros et al (2016). The authors attribute such development to the heterogeneous characteristics of various portfolio components.

We find that the increased performance of the risk-minimizing portfolios during crisis is broadly narrowed to the long-run fluctuations (shorter scales). Such higher performances at shorter scales suggest that, during the crises, investors were not willing to invest over long-term horizons. This explains why some African markets experienced first-round effect of the global financial crisis despite the theoretical view that African economies could potentially be decoupled from global economic shocks during crisis.[9] Thus, although the decoupling phenomenon may hold for African markets during global financial crisis, if investors decide to balance their portfolios only for the short-term, the portfolio reversals may cause serious effects to the continent. This view is empirically supported by Simatele (2014) which established that the GFC recorded some drops in portfolio flows to Africa due to increased investor risk-aversion, tighter global credit conditions, and developments in the bond markets. The post-crisis declines may also be attributable to international investors' failure to see investments in Africa as viable alternatives (AfDB, 2013; Simatele, 2014).

Table 3: Frequency risk-adjusted performance: Undiversified portfolios

	D1		D2		D3		D4		D5		D6		S6	
	SR	*GSR*	*SR*	*GSR*	*SR*	*GSR*	*SR*	*GSR*	*SR*	*GSR*	*SR*	*GSR*	*SR*	*GSR*
Panel A: 1996-2018														
Nigeria	0.93	1.09	3.06	2.73	1.21	1.23	-0.29	-0.28	0.25	0.26	0.15	0.02	0.16	0.03
Botswana	-1.33	-1.36	-1.83	-1.98	0.65	0.67	0.55	0.56	0.24	0.26	0.10	0.21	0.17	0.03
Tunisia	-1.28	-1.27	0.06	0.06	-0.56	-0.62	-0.12	-0.12	0.11	0.12	-0.02	0.33	-0.05	0.00
Cote d'Ivoire	-0.27	-0.28	-0.04	-0.04	0.38	0.41	0.19	0.20	0.03	0.03	0.12	0.11	0.08	0.01
Ghana	-3.32	-4.27	-3.35	-1.90	-1.04	-1.17	0.07	0.07	-0.33	-0.34	0.05	0.00	-0.10	0.01
Kenya	-0.56	-0.60	-0.80	-0.95	0.26	0.28	0.13	0.13	0.18	0.19	0.21	-0.34	0.16	0.03
South Africa	0.35	0.34	0.22	0.22	-0.51	-0.57	0.19	0.20	0.05	0.05	0.12	-0.05	0.08	0.01
Egypt	0.24	0.25	1.21	1.12	0.45	0.48	-0.15	-0.15	-0.11	-0.10	0.26	0.15	0.15	0.02
Morocco	-0.21	-0.21	-0.14	-0.14	0.61	0.55	0.61	0.60	0.12	0.12	-0.03	-0.03	0.07	0.00
Oil	0.21	0.20	0.12	0.12	-0.03	-0.03	0.00	0.00	0.35	0.35	0.09	0.11	0.12	0.01
Cocoa	0.49	0.52	0.28	0.30	0.20	0.20	0.38	0.39	-0.04	-0.04	0.00	0.02	0.01	0.00
Coffee	0.64	0.69	-0.20	-0.20	0.80	0.84	-0.14	-0.14	-0.10	-0.10	0.02	-0.04	0.01	0.00
Tea	0.53	0.53	0.14	0.14	0.45	0.48	0.26	0.26	0.03	0.03	-0.05	-0.11	0.01	0.00
Cotton	-2.15	-3.08	-0.93	-1.06	0.48	0.49	0.08	0.08	-0.02	-0.02	-0.05	-0.00	-0.05	0.00
Gold	-5.36	-6.53	-0.24	-0.24	-0.37	-0.38	0.07	0.07	0.10	0.10	0.07	-0.31	0.02	0.00
Energy	-0.18	-0.18	0.15	0.15	0.03	0.03	0.02	0.02	0.39	0.39	0.07	0.07	0.11	0.01
Beverages	0.73	0.56	-0.34	-0.35	0.69	0.74	0.02	0.02	-0.12	-0.12	0.00	0.00	-0.01	0.00
Agriculture	0.37	0.41	-0.74	-0.84	0.19	0.19	-0.01	-0.01	0.04	0.04	-0.02	-0.02	-0.03	0.00
Precious Metals	-3.43	-1.75	-0.32	-0.34	-0.38	-0.38	0.12	0.13	0.11	0.11	0.07	0.07	0.03	0.00
Diamond														
Panel B: 1996-2000														
Nigeria	1.23	2.22	-2.71	-1.36	6.28	3.23	-0.29	-0.28	0.11	0.11			0.10	0.10
Botswana	0.22	-0.31	4.84	3.42	5.27	0.67	0.55	0.56	0.09	0.09			0.16	0.17
Tunisia	-0.11	-3.77	-0.08	0.96	0.35	-0.62	-0.12	-0.12	0.05	0.05			-0.13	-0.13

Cote d'Ivoire	2.44	3.12	5.19	3.60	5.62	0.41	0.19	0.20	-0.08	-0.08			-0.03	-0.03
Ghana	-3.18	-0.14	-2.22	-0.11	-1.79	-1.17	0.07	0.07	-0.60	-0.61			-0.44	-0.44
Kenya	-0.55	0.00	-0.16	-1.57	-4.70	0.28	0.13	0.13	0.06	0.06			0.03	0.03
South Africa	0.01	1.11	0.08	0.92	0.27	-0.57	0.19	0.20	-0.03	-0.03			-0.01	-0.01
Egypt	-2.11	-5.16	-3.95	-0.98	0.51	0.48	-0.15	-0.15	-0.20	-0.20			-0.01	-0.01
Morocco	1.32	-3.44	2.61	2.31	-3.52	0.55	0.61	0.60	-0.03	-0.03			0.16	0.17
Oil	0.21	2.33	-1.11	0.45	3.04	-0.03	0.00	0.00	0.26	0.26			0.10	0.10
Cocoa	-0.38	-2.51	-3.58	-0.79	-0.68	0.20	0.38	0.39	-0.35	-0.34			-0.12	-0.12
Coffee	-0.42	-1.66	3.26	2.63	5.15	2.84	-0.14	-0.14	-0.31	-0.30			-0.06	-0.06
Tea	0.71	0.92	-0.55	0.73	3.69	0.48	0.26	0.26	-0.10	-0.10			0.04	0.04
Cotton	-0.27	-3.08	1.19	1.60	-0.12	0.49	0.08	0.08	-0.07	-0.07			-0.10	-0.10
Gold	-4.22	-5.11	-4.62	-1.31	1.62	-0.38	0.07	0.07	-0.10	-0.10			-0.17	-0.16
Energy	-3.15	-0.03	2.85	0.24	-4.19	0.03	0.02	0.02	0.31	0.32			0.11	0.12
Beverage	-0.31	1.82	-1.53	2.58	3.28	0.74	0.02	0.02	-0.44	-0.43			-0.12	-0.12
Agriculture	3.11	-3.39	3.15	1.72	-1.10	0.19	-0.01	-0.01	-0.18	-0.18			-0.18	-0.17
Precious Metal	0.29	-1.95	1.07	-2.44	3.58	-0.38	0.12	0.13	-0.11	-0.10			-0.15	-0.15
Diamond														
Panel C: 2001-2006														
Nigeria	2.90	0.00	1.71	1.36	0.78	0.80	0.55	0.58	-0.26	-0.26	0.27	0.28	0.19	0.04
Botswana	1.61	1.91	1.70	2.31	0.95	1.08	0.61	0.69	-0.43	-0.43	0.44	0.47	0.20	0.04
Tunisia	1.45	1.97	0.48	0.53	0.63	0.69	0.46	0.50	-0.52	-0.54	0.31	0.30	0.03	0.00
Cote d'Ivoire	1.88	1.65	0.66	0.73	0.61	0.59	0.51	0.53	-0.14	-0.14	0.02	0.02	0.15	0.02
Ghana	3.22	3.18	1.20	1.62	0.62	0.64	0.90	1.07	-0.60	-0.58	0.07	0.07	0.10	0.01
Kenya	1.74	1.69	1.44	1.97	0.45	0.47	1.07	1.19	-0.23	-0.23	0.55	0.60	0.24	0.06
South Africa	1.05	1.30	0.88	0.96	0.34	0.35	0.42	0.44	-0.27	-0.29	0.09	0.09	0.13	0.02
Egypt	0.59	0.60	0.25	0.27	0.63	0.66	0.81	0.90	0.00	0.00	0.38	0.36	0.28	0.08
Morocco	1.19	1.07	0.75	0.68	0.48	0.48	0.23	0.25	-0.45	-0.46	0.45	0.51	0.05	0.00

	D1		D2		D3		D4		D5		D6		S6	
	SR	GSR	SR	GSR	SR	GSR	SR	GSR	SR	GSR	SR	GSR	SR	GSR
Oil	3.83	0.00	0.72	0.82	0.70	0.77	0.60	0.58	-0.32	-0.32	-0.13	-0.13	0.13	0.02
Cocoa	0.93	1.07	0.44	0.48	1.22	1.20	0.34	0.34	-0.63	-0.66	0.07	0.07	0.08	0.01
Coffee	2.82	2.74	0.46	0.49	0.90	0.93	0.34	0.37	-0.33	-0.33	0.09	0.09	0.09	0.01
Tea	2.25	1.22	1.40	1.52	0.69	0.67	0.55	0.60	-0.63	-0.66	-0.11	-0.11	-0.02	0.00
Cotton	1.80	0.61	0.34	0.37	0.72	0.72	0.91	1.07	-0.61	-0.64	-0.10	-0.10	-0.03	0.00
Gold	2.02	2.47	0.93	1.12	0.91	1.03	0.61	0.69	-0.47	-0.51	0.09	0.09	0.11	0.01
Energy	3.95	7.44	0.56	0.61	0.74	0.82	0.54	0.55	-0.37	-0.36	-0.10	-0.10	0.10	0.01
Beverages	1.76	2.26	0.61	0.67	1.06	1.05	0.44	0.47	-0.60	-0.64	0.13	0.13	0.07	0.00
Agriculture	2.86	4.11	1.07	1.30	0.78	0.81	0.63	0.73	-0.64	-0.71	0.06	0.06	0.04	0.00
Precious Metals	2.39	3.06	0.90	1.07	0.92	1.03	0.62	0.71	-0.41	-0.45	0.12	0.12	0.12	0.01
Diamond	-2.01	-2.18	-1.90	-1.56	-1.07	-1.27	-0.12	-0.12	-0.25	-0.25			-0.29	0.09
Panel D: 2007-2010														
Nigeria	2.42	2.82	1.26	1.31	0.40	0.38	-0.17	-0.19	-0.10	-0.10			-0.05	-0.05
Botswana	1.44	0.89	2.23	2.31	0.18	0.17	-0.13	-0.14	-0.07	-0.07			-0.05	-0.05
Tunisia	1.26	1.58	0.47	0.45	0.58	0.56	-0.12	-0.12	-0.04	-0.04			-0.03	-0.03
Cote d'Ivoire	1.14	1.04	2.12	2.15	0.61	0.56	-0.16	-0.17	-0.05	-0.05			-0.35	-0.39
Ghana	1.08	0.93	0.92	0.93	0.53	0.50	-0.17	-0.18	0.05	0.05			-0.19	-0.19
Kenya	-0.34	-0.37	0.72	0.83	0.44	0.46	-0.12	-0.13	-0.02	-0.02			-0.29	-0.31
South Africa	0.50	0.55	2.31	0.55	0.67	0.63	-0.17	-0.18	0.02	0.02			-0.31	-0.32
Egypt	1.32	1.08	0.72	0.70	0.40	0.37	-0.14	-0.15	-0.15	-0.15			-0.45	-0.49
Morocco	0.50	0.45	0.33	0.35	0.53	0.48	-0.12	-0.13	-0.16	-0.16			-0.39	-0.42
Oil	0.25	0.23	1.02	1.29	0.68	0.62	-0.13	-0.14	-0.03	-0.03			-0.39	-0.43
Cocoa	1.28	0.73	0.48	0.52	0.42	0.41	-0.12	-0.13	-0.08	-0.08			-0.45	-0.50
Coffee	-0.81	-0.83	1.00	1.10	0.40	0.39	-0.12	-0.13	0.02	0.02			-0.27	-0.29
Tea	0.51	0.58	1.18	1.28	0.51	0.51	-0.10	-0.11	-0.09	-0.09			-0.39	-0.43
Cotton	0.20	0.20	0.77	0.95	0.41	0.38	-0.14	-0.15	0.10	0.10			-0.13	-0.13

Gold	0.88	0.88	0.66	0.63	0.50	0.45	-0.12	-0.13	-0.02	-0.02		-0.32	-0.34
Energy	0.37	0.33	0.99	1.15	0.65	0.62	-0.14	-0.15	-0.03	-0.03		-0.37	-0.41
Beverage	0.72	0.67	1.06	1.33	0.42	0.41	-0.12	-0.13	-0.05	-0.05		-0.37	-0.40
Agriculture	1.32	1.24	1.15	1.29	0.54	0.52	-0.13	-0.14	-0.04	-0.04		-0.33	-0.36
Precious Metal	0.72	0.72	0.64	0.63	0.49	0.45	-0.13	-0.14	0.00	0.00		-0.30	-0.32
Diamond	-0.09	-0.09	0.23	0.23	-0.32	-0.30	-0.56	-0.56	-0.01	-0.01		0.24	0.24
Panel E: 2011-2018													
Nigeria	3.98	4.23	1.16	1.05	-0.50	-0.54	0.45	0.45	-0.27	-0.32	-0.20	-0.23	-0.57	-0.61
Botswana	2.67	1.80	1.11	1.03	-0.49	-0.53	0.23	0.23	-0.26	-0.30	-0.20	-0.23	-0.88	-1.11
Tunisia	1.25	1.36	1.24	1.17	-0.47	-0.51	0.19	0.19	-0.26	-0.30	-0.21	-0.24	-0.81	-0.91
Cote d'Ivoire	2.77	3.45	1.04	0.96	-0.47	-0.50	0.31	0.31	-0.25	-0.28	-0.19	-0.22	-0.92	-1.10
Ghana	2.45	1.89	1.44	1.21	-0.54	-0.58	0.40	0.41	-0.28	-0.33	-0.20	-0.23	-0.55	-0.58
Kenya	2.73	2.65	1.34	1.14	-0.50	-0.53	0.44	0.44	-0.24	-0.28	-0.18	-0.21	-0.76	-0.87
South Africa	2.52	3.19	1.41	1.27	-0.48	-0.51	0.30	0.29	-0.26	-0.30	-0.20	-0.22	-0.69	-0.80
Egypt	2.38	0	0.81	0.80	-0.45	-0.47	0.26	0.26	-0.26	-0.30	-0.19	-0.22	-0.64	-0.73
Morocco	2.35	2.96	1.13	1.15	-0.47	-0.50	0.16	0.16	-0.26	-0.30	-0.20	-0.23	-0.74	-0.84
Oil	2.08	2.29	0.95	0.87	-0.48	-0.51	0.24	0.24	-0.28	-0.33	-0.57	-0.59	-0.20	0.00
Cocoa	3.58	2.21	1.04	1.04	-0.52	-0.56	0.23	0.23	-0.25	-0.28	-0.89	-1.09	-0.21	0.00
Coffee	4.02	0.00	1.03	0.94	0.14	0.13	0.13	0.13	-0.25	-0.29	-0.84	-0.96	-0.21	0.00
Tea	2.23	2.29	1.21	1.07	0.14	0.13	0.28	0.28	-0.26	-0.30	-0.69	-0.85	-0.20	0.00
Cotton	3.08	2.83	0.52	0.49	-0.51	-0.55	0.21	0.21	-0.27	-0.31	-0.70	-0.80	-0.21	0.00
Gold	2.33	1.83	1.23	1.17	-0.46	-0.50	0.17	0.17	-0.26	-0.30	-0.79	-0.92	-0.20	0.00
Energy	2.74	2.67	1.05	0.95	-0.48	-0.52	0.21	0.21	-0.28	-0.33	-0.55	-0.58	-0.20	0.00
Beverage	3.72	0.00	1.08	1.01	-0.51	-0.56	0.20	0.20	-0.25	-0.29	-0.85	-1.03	-0.21	0.00
Agriculture	4.00	0.00	1.12	1.04	-0.49	-0.53	0.21	0.21	-0.26	-0.31	-0.82	-0.98	-0.21	0.00
Precious Metal	2.26	1.70	1.15	1.06	-0.47	-0.50	0.16	0.16	-0.26	-0.30	-0.78	-0.90	-0.20	0.00
Diamond	0.88	0.88	0.48	0.40	-0.89	-0.99	-0.74	-0.84	-0.56	-0.54	-1.37	-1.50	-0.39	0.17

Risk-return trade-off analysis

To examine risk-return trade-offs of portfolio investments in the African markets, we specify an extension of the capital asset pricing model (CAPM) – see also Anghelache (2012) and Keith and Nitzsche (2005). The estimation of the CAPM model in this study is done for the full sample period. However, in order to capture effects of the GFC, a dummy variable (D_t) taking the value one (1), during the GFC period and zero (0) otherwise is chosen. We estimate this model to determine the global index that exerts the highest influence on Africa's unexpected average excess returns on risk-adjusted basis in the full-sample and GFC period. The extended excess return market model (static approach) is specified with D_t as:

$$(r_{it} - r_f) = \beta_0 + \beta_1(r_{mit} - r_f) + \beta_2 D_t + \varepsilon_t \quad (8)$$

where, r_{it} = returns on African stocks; r_{mit} = returns on global indexes (BCOM, SandP 500, and MSCI-W), which serve as benchmark market portfolios; ε_t is the error; r_f = risk-free interest rate (in this case, considered as the U.S one-month treasury bill rate)[10] since returns are measured in US$.[11] We use the main U.S market (i.e., SandP 500) because the U.S remains the main origination point for the 2008-2009 financial crises, and thus, our main epicentre for capturing the effects of the GFC. The Morgan Stanley Capital International World index (MSCI-W), which includes developed and emerging markets is also included because of the diversity in its composition (i.e., it is made up of both developed and emerging markets).

To be able to capture the impact of the global commodities (GC) on the African stocks, the following augmented market model is specified, similar to Lean and Nguyen (2014).

$$(r_{it} - r_f) = \alpha_0 + \beta^*_0(r_{mit} - r_f) + \sum_{j=1}^{n} \alpha_j \Delta \mathrm{h}(G\ )_j + D_t\left[\delta_0 + \beta^*_1(r_{mit} - r_f) + \sum_{j=1}^{n} \delta_j \Delta \mathrm{h}(G\ )_j\right] + \varepsilon_t \quad (9)$$

where, β^*_0 and β^*_1 are measures of market-wide risk (computed as the covariance of the return of an asset with the return of the benchmark divided by the variance of the return of the benchmark over the sample period) in the full sample and GFC periods, respectively; *n* is the total number of commodities; $\alpha_j\ (j = 1,2,...,5)$ and $\delta_j\ (j = 1,2,...,5)$ denote the marginal effects of the commodities on equities in Africa for the full sample and GFC periods, respectively. All other notations are as previously defined in Equation 8.

The estimated CAPM model in Equation 8 provides a standard approach for assessing the risk associated with investing in the African stock markets with respect to the global market indexes (i.e., SandP 500, BCOM, and MSCI-W). Equation 8 is estimated for all nine African stock markets in a static framework. The country-by-country estimation results together with two measures of risk-adjusted performance are shown in Table 4. The empirical results are discussed as follows.

Although the Shape-Lintner version of the CAPM suggests that the Jensen's alpha

(the intercept or constant term) should be zero, it can be observed from Table 4 that the country-by-country constants are negative (less than zero) and significant at the 1% level. The results suggest that during the sample period, investments in the African stocks underperformed those in the global markets; making African stocks generally less attractive to foreign investors at normal periods.

Results from the estimated beta (β_1) indicating the sensitivity of the African stocks to the market-wide source of risk (systematic risk) possibly arising from global markets volatility confirms the signs and magnitude of the Jensen alphas. Results relating to the dummy, D_t representing the effect of the GFC (β_2) indicates that the performances of all the markets were negatively affected by the GFC at varying significance levels with SandP 500 as the benchmarked global market. This corroborates the view by Giovannetti and Velucchi (2013) that shocks from the collapse of Lehman Brothers (around September 2008) had more relevant impact on African stock markets; and that South Africa and Nigeria received immediate impact, with shocks persistent even after the period of the Lehman Brothers. More closely related to our findings is the observation by Beck et al (2009) that propagation of shocks from the GFC had a second round effect in Africa. Thus, the impact of the GFC to African economies was not through the credit crunches and liquidity freezes in the pre-2008 periods (i.e., Phase 1), but rather through the global recession that followed into the second phase (i.e., between 2008 and 2009).

With the Bloomberg Commodity Index as the global market, significant positive effects are noticed except for Botswana, Egypt, Ghana, Kenya, and Nigeria. Similarly, in the case of the MSCI-W, only Nigeria and Ghana are seen to have escaped the effects of the financial crisis. Although the dynamics appear a bit intricate to explain, the susceptibility of markets to adverse effects from the MSCI-W index during the GFC may rest on the market's liquidity levels and the real sector of their economies. South Africa and Egypt remain the largest and most liquid markets in Africa, and therefore are likely to be the most integrated with global capital flows.

Table 4: Estimation results of the static market model and risk-adjusted performance measures

	Static Market Model Results (*full sample period with D_t*) – Eqn. 8				Risk-Adjusted Performance Measures			
					Full Sample Period		***Crisis Period***	
Market	β_0	β_1	β_2	DW	Tracking Error	Information Ratio	Tracking Error	Information Ratio
Panel A: SandP 500 as the benchmark global market								
BOTSWANA	-0.418[-13.212]***	0.686[49.539]***	-0.656[-20.451]***	2.03	0.974	0.002	0.834	-0.039
COTE D'IVOIRE	-0.327[-9.158]***	0.727[47.243]***	-0.730[-19.039]***	2.01	1.334	0.032	1.163	-0.008
EGYPT	-0.370[-7.659]***	0.682[33.225]***	-0.590[-12.243]***	2.01	1.774	0.031	1.822	-0.022
GHANA	-0.44[-12.707]***	0.671[-44.105]***	-0.671[-20.897]***	2.08	0.983	-0.003	1.016	-0.030
KENYA	-0.345[-7.975]***	0.425[26.076]***	-0.267[-8.506]***	2.02	1.152	0.010	0.958	-0.035
MOROCCO	-0.452[-12.074]***	0.669[41.745]***	-0.616[-16.530]***	2.03	1.289	-0.008	1.443	-0.077
NIGERIA	-0.487[-9.098]***	0.352[19.882]***	-0.216[-6.761]***	2.02	1.296	-0.001	1.402	-0.061
SOUTH AFRICA	-0.342[-7.551]***	0.734[37.806]***	-0.799[-16.238]***	2.00	1.797	0.011	1.989	-0.005
TUNISIA	-0.310[-10.212]***	0.373[31.203]***	-0.375[-16.472]***	2.03	0.671	0.020	0.752	-0.036
Panel B: Bloomberg Commodity Index as the benchmark global market								
BOTSWANA	-0.308[-8.705]***	0.393[26.636]***	0.165[1.381]	2.03	1.004	0.032	0.877	0.012
COTE D'IVOIRE	-0.435[-10.642]***	0.629[37.941]***	0.243[1.715]*	2.02	1.364	0.053	1.206	0.028
EGYPT	-0.451[-8.547]***	0.606[29.181]***	0.218[1.180]	2.02	1.804	0.047	1.865	0.002
GHANA	-0.266[-7.083]***	0.389[26.588]***	-0.151[-1.185]	2.04	1.013	0.026	1.059	0.012
KENYA	-0.365[-7.796]***	0.373[24.282]***	0.103[0.641]	2.02	1.182	0.035	1.001	0.010
MOROCCO	-0.585[-13.540]***	0.565[33.173]***	0.455[3.014]***	2.06	1.318	0.015	1.486	-0.045
NIGERIA	-0.613[-9.540]***	0.264[15.464]***	0.174[0.783]	2.04	1.326	0.021	1.445	-0.030
SOUTH AFRICA	-0.421[-8.532]***	0.662[33.359]***	0.355[2.077]**	2.01	1.827	0.027	2.032	0.016
TUNISIA	-1.171[-11.050]***	0.065[5.172]***	0.677[1.870]*	2.69	0.701	0.061	0.795	0.020
Panel C: Morgan Stanley Capital International World Index as the benchmark global market								
BOTSWANA	-0.322[-9.383]***	0.378[23.227]***	0.322[2.749]***	2.02	0.976	0.008	0.847	-0.023

COTE D'IVOIRE	-0.431[-10.570]***	0.649[38.977]***	0.369[2.596]***	2.01	1.336	0.033	1.176	0.003
EGYPT	-0.446[-8.535]***	0.625[29.717]***	0.339[1.851]*	2.01	1.775	0.032	1.834	-0.015
GHANA	-0.290[-7.932]***	0.417[25.293]***	0.017[0.139]	2.03	0.985	-0.002	1.028	-0.018
KENYA	-0.419[-8.866]***	0.361[20.711]***	0.276[1.703]*	2.01	1.154	0.012	0.971	-0.021
MOROCCO	-0.538[-12.980]***	0.616[36.703]***	0.540[3.733]***	2.03	1.290	-0.007	1.456	-0.067
NIGERIA	-0.588[-9.647]***	0.290[15.749]***	0.261[1.231]	2.02	1.298	3.03e-05	1.414	-0.052
SOUTH AFRICA	-0.410[-8.364]***	0.688[34.431]***	0.482[2.821]***	2.00	1.799	0.012	2.002	0.001
TUNISIA	-1.103[-11.518]***	0.087[6.347]***	0.722[2.167]**	2.65	0.673	0.022	0.764	-0.019

Notes: ***, **, * denote statistical significance at the 0.01, 0.05, and 0.1 levels, respectively. Figures in brackets [] represent test statistics. DW is the Durbin-Watson statistic indicating the absence of any remaining autocorrelation in the series.

It would then be expected that these markets would be the most susceptible to contagion. The case of Nigeria and Ghana is a bit difficult to explain considering their size in the West African regional bloc and Africa and also how well-traded they are among emerging markets, although not at the levels of Egypt and South Africa. Whilst the above reasons may sound plausible, giving that the extent of markets integration in Africa is not high as compared to their developed counterparts – other channels such as the share of foreign-owned banks in a country, drop in international capital flows, and changes in the overall international regulatory architecture and the real economy (see also, Beck et al, 2009; Ncube et al, 2014; Simatele, 2014) may account for this.

The above results suggest that, depending on which global asset is under consideration, the effect of the crisis is uneven. The differences in the effects from the global assets may be accounted for by the differences in their compositions. For example, although the SandP 500 and MSCI-W indexes are value-weighted and computed with dividends re-invested, the MSCI-W index reflects assets of both developed and emerging markets; and is more similar to widely quoted country index returns (Harvey, 1991 as cited in Kodongo and Kalu, 2011). This suggests that the African country index returns are more comparable to the MSCI-W returns more than the SandP 500 returns, which reflects only U.S-based assets. We wish to intuit that, the effects from the GFC to Africa were non-homogenous for individual countries. Commodity driven economies such as Nigeria, South Africa, Botswana, and Kenya suffered from drops in export prices and volumes, as well as demand for commodities, among other factors. In Botswana, lower diamond sales to financially depressed European markets during the crisis made the domestic economy highly vulnerable to shifts in global economies that consume the country's diamond (see also Abdullahi and Mmolainyane, 2014). Since the Botswana market has higher weightings towards the diamond industry, the consequential effects on the local bourse was noticeable.

Further to the static model is the examination of some risk-adjusted performance of the African equities relative to the benchmark global markets (i.e., SandP 500, BCOM, and MSCI-W) presented in columns 6-9 of Table 4. The market cycle comparisons are done on the basis of tracking errors (TRs) and information ratios (IRs) of the African stocks. First, the tracking error or active risk computed as the variance of the standard deviation of Africa's equities and the benchmark's returns aids in addressing the question of how much returns on African stocks, on average, deviated from that of the benchmark during the full-sample and GFC periods. A lower TR indicates the proximity of the two returns and less risk.

It is clear from Table 4 that across all benchmarks and the two sample periods, Tunisia and South Africa recorded the lowest and highest TRs, respectively. South Africa's highest TR means that diversifying across the FTSE/JSE (Johannesburg Stock Exchange) was more risky than across other African markets. Since TRs fail to establish outperformance and underperformance, it is unclear at this point whether the additional risk was worth it for international investors who decided to include South African stocks in a diversified portfolio. The IR rather helps in addressing this puzzle. The IR is defined as the quotient of the asset's (African stock) average mean

excess returns relative to the benchmark's average mean return and the variability of that excess return. It helps to ascertain how much excess returns are generated for a unit additional risk taken with the inclusion of an African stock in a diversified portfolio relative to the benchmark.

A critical observation from the results suggests that any additional risk tolerated for investing in the South African equity market in both the full-sample and GFC periods was not worth it since the IRs are highly anaemic compared to other markets, and international standards. It thus appears that the Egyptian market offers a better alternative with slightly similar TRs in the full sample period as that of South Africa and higher IRs than South Africa. However, during the GFC, the Egyptian market records negative IRs with the BCOM and MSCI-W benchmarks. The African equities record relatively large numbers of negative IRs with the SandP 500 and MSCI-W as benchmark portfolios. This supports the findings of Goodwin (2009) that managers who benchmark against the SandP 500 index obtain lower IRs.

Next, we present results of the augmented market model in Table 5, where the impact of the global factors and the crisis on the African markets are estimated. The findings are discussed as follows. Analogous to the static market model results, the constant terms (α_0) are all negative and significant. Again, the African stocks underperform the average returns on related global investments. It is informative to note that only Morocco, Ghana, and Tunisia are dependent on changes in the market-wide returns (as measured by δ_0), during the GFC period. For all stocks, the betas are positive during full-sample period (β_0^*) and negative during crisis era (β_1^*). The inference is that the ability of African stocks to shield international portfolio investors from adverse shocks, during the crisis was minimal. Simatele (2014) reports that the most immediate effect of the GFC on Africa's equity markets was the flight of portfolio investments, mainly on account of increased risk aversion, tighter global credit conditions, and developments in the bond markets. Baur and McDermott (2010) have observed that, relative to developed markets, emerging markets fail to provide protection for traditional assets (such as stocks and bonds) during global market turmoil. The plausible reason may be that increased global market uncertainties during extreme periods cast a shadow of doubt on the potentials of emerging markets to offer higher expected rewards. Fuelled by market uncertainty, investor sentiments and risk-aversion, international portfolio investors may pull out their holdings in African equities during crisis periods leading to greater impact. Instead, on the balance of probability of success, they may prefer to shift their portfolios towards the relative safety of developed world markets (Baur and McDermott, 2010).

Table 5: Augmented market model results (full sample period)

Market	α_0	β_0^*	α_1	α_2	α_3	α_4	α_5	δ_0	β_1^*	δ_1	δ_2	δ_3	δ_4	δ_5	*DW*
Panel A: SandP 500 as the global market															
BOTSWANA	-0.41***	0.70***	0.04***	0.03***	0.01	0.01	0.01	0.12	-0.66***	0.05*	-0.00	0.06	-0.01	0.04	2.02
COTE D'IVOIRE	-0.32***	0.73***	0.05***	0.02	0.01	0.00	-0.00	-0.03	-0.73***	0.07**	-0.04	-0.01	-0.00	-0.00	2.00
EGYPT	-0.37***	0.68***	0.01	0.03	-0.00	0.00	0.02	0.03	-0.59***	0.11***	-0.02	0.10	0.01	0.01*	2.01
GHANA	-0.42***	0.69***	0.01	-0.01	0.00	-0.02	-0.00	-0.17	-0.69***	0.01	-0.22	-0.01	-0.00	0.01	2.07
KENYA	-0.36***	0.42***	0.01	0.01	0.00	0.01	0.00	0.09	-0.27***	0.00	-0.02	0.14***	0.02	-0.02	2.02
MOROCCO	-0.46***	0.68***	0.07***	0.03**	-0.01	0.00	0.01*	0.22*	-0.62***	0.06*	-0.03	-0.00	-0.02**	0.01	2.02
NIGERIA	-0.49***	0.35***	-0.02	0.01	-0.00	0.00	0.00	0.10	-0.21***	-0.01	-0.03	0.08**	-0.01	-0.00	2.02
SOUTH AFRICA	-0.28***	0.78***	0.35***	0.10***	0.02	-0.01	-0.00	0.05	-0.83***	0.01	0.10***	0.12**	0.00	-0.00	1.99
TUNISIA	-0.33***	0.37***	0.05***	0.03***	-0.01	0.00	-0.01	0.17	-0.37***	-0.01	0.02	0.01	0.00	0.03	2.05
Panel B: Bloomberg Commodity Index as the global market															
BOTSWANA	-0.28***	0.43***	0.03**	0.04***	0.01	0.00	-0.00	0.07	-0.29***	0.05**	-0.03	0.05	0.00	0.00	2.03
COTE D'IVOIRE	-0.36***	0.68***	0.03**	0.03*	0.01	0.00	-0.00	0.03	-0.60***	0.08**	-0.05*	-0.02	0.00	-0.02	2.01
EGYPT	-0.36***	0.67***	0.00	0.03*	0.00	0.01	-0.02	-0.00	-0.63***	0.11***	-0.03	0.09	0.00	-0.00	2.01
GHANA	-0.23***	0.44***	0.00	-0.00	0.01	-0.02	0.02	-0.28**	-0.39***	0.02	-0.05**	-0.01	0.02	0.00	2.03
KENYA	-0.35***	0.38***	0.01	0.01	0.01	0.00	0.01	0.07	-0.06	0.02	-0.01	0.12***	-0.00	0.02	2.00

MOROCCO	-0.50***	0.63***	0.06***	0.04***	-0.01	0.00	0.00	0.26*	-0.49***	0.06*	-0.03	-0.01	-0.00	-0.00	2.04
NIGERIA	-0.56***	0.30***	-0.02	0.02	0.00	-0.01	-0.01	0.08	-0.22***	0.01	-0.02	0.07*	0.01	0.00	2.04
SOUTH AFRICA	-0.31***	0.74***	0.33***	0.11***	0.02	0.02	-0.00	0.13	-0.63***	0.02	0.10***	0.10*	-0.00	0.00	2.00
TUNISIA	-0.04***	0.16***	0.06***	0.03***	-0.01	-0.01	0.00	0.01	-0.20***	0.01	0.01	-0.03	0.00	0.00	2.19
Panel C: Morgan Stanley Capital International World Index as the global market															
BOTSWANA	-0.33***	0.75***	0.04***	0.03**	0.01	0.00	-0.00	0.01	-0.78***	0.05*	-0.00	0.05	0.00	-0.01	2.02
COTE D'IVOIRE	-0.27***	0.77***	0.05***	0.02	0.01	-0.01	-0.01	-0.09	-0.80***	0.07**	-0.04	-0.01	0.02	-0.01	2.00
EGYPT	-0.30***	0.73***	0.01	0.03	0.00	-0.01	-0.02	-0.06	-0.70***	0.11***	-0.02	0.09	0.00	-0.00	2.00
GHANA	-0.31***	0.76***	0.01	-0.02	0.01	-0.01	0.01	-0.27**	-0.74***	0.01	-0.02	-0.01	-0.00	-0.00	2.04
KENYA	-0.32***	0.47***	0.02	0.00	0.01	0.01	0.00	0.03	-0.41***	0.02	0.01	0.14***	-0.03**	0.03	1.99
MOROCCO	-0.39***	0.73***	0.07***	0.03**	-0.01	0.01	-0.01	0.16	-0.64***	0.05*	-0.03	-0.01	0.00	0.00	2.02
NIGERIA	-0.45***	0.40***	-0.01	0.01	0.00	-0.00	-0.02	0.03	-0.36***	0.00	0.01	0.08**	-0.01	-0.01	2.00
SOUTH AFRICA	-0.23***	0.82***	0.35***	0.10***	0.02	0.00	0.00	0.02	-0.81***	0.01	0.10***	0.11*	-0.02	-0.00	1.99
TUNISIA	-0.35***	0.44***	0.06***	0.02***	-0.00	-0.01*	-0.00	0.33***	-0.39***	-0.01	0.03**	0.01	-0.00	0.04	2.09

Notes: ***, **, * indicate statistical significance at the 0.01, 0.05, and 0.10 level, respectively; and DW is the Durbin-Watson statistics indicating the absence of any remaining autocorrelation in the series. δ_0 is the parameter capturing the effect of the GFC.

The regressors GOLD, OIL, COCOA, COFFEE, COTTON, respectively, relate to the coefficients α_1, δ_1; α_2, δ_2; α_3, δ_3; α_4, δ_4; and α_5, δ_5. α_0 is the intercept; and β_0^*, β_1^* are the coefficients for the excess global markets in the full-sample and sub-sample periods, respectively.

While the above constitute a somewhat simplistic intuitive approach to explaining the dynamics, its plausibility is intact. The negative effects of the GFC on African markets could also be attributed to the effects on trade balances possibly arising from export demand shocks and price movements of key commodities. In most of the African economies, for example South Africa, the spill-over effects was also felt through a deteriorating overall economy (Simatele, 2014). The slump in the economic aggregates registered heightened pressure on individual country's balance of payment with consequential effects on domestic exchange rates, overall gross domestic product (GDP) and financial sectors, without corresponding increases in portfolio investments flows. For example, at the peak of the crisis in 2008, no African country issued bonds and already existing ones were either cancelled or postponed (Kasekende et al, 2009; Brambila-Macias and Massa, 2010).

Results for the commodities in both the full and GFC periods vary from market to market. A dollar increase in the price of gold is seen to exert significant positive effects on the average returns of six African stock markets in the two regimes. The effects of oil price increases are positive for the affected markets in the full-sample period. However, some negative effects are recorded in the crisis periods for Cote D'Ivoire and Ghana. Rising cocoa prices have significant positive effects on the average daily returns of Kenya, Nigeria, and South Africa in the post-crisis era.

5. Conclusion

Africa's economies have huge commodities endowment, which make most of them highly dependent on commodities. At the same time, these economies are seen as relatively less integrated with most global asset markets, including the financial markets for commodities. To what extent does the dynamic relationship between African stocks and commodity prices hold discernible implications for equity-commodities investors seeking to diversify across uncorrelated assets? In this study, we examine the time-scale connectedness and risk-sharing behaviour between returns on African stock markets and commodities across the energy, agriculture, metals, and beverage commodities using data of monthly periodicity from 1996 to 2017.

First, we examine multi-scale (short-, medium-, and long-run) wavelet structural relationships between African stocks and commodities using the bivariate wavelet coherence. We establish that, commodities and African stock returns co-move across multiple scales and co-integrate in the long run, albeit sparse, as evidenced by the high value of the wavelet multiple correlation coefficients (WMC) over increasing scales. Second, we find possible lead–lag relationship between the markets through a linear combination of all variables. We estimate wavelet multiple cross-correlation (WMCC) values for all three series. From the wavelet multiple cross-correlation values, we find that of all the nine stock markets, it is only the Ivory Coast regional bourse that maximizes the multiple correlations against the linear combinations of the aggregate commodity indexes. However, due to the symmetric nature of the cross-correlation plots, we cannot arrive at a definitive conclusion as to whether the market leads others.

Finally, we analyse portfolio performances of African stock markets with other commodities using wavelet-based diversified and undiversified portfolios. Here, we apply the wavelet test in a translation-invariant manner, using both detail and smooth coefficients to calculate the scale-specific Sharpe ratios over different sub-periods in the sample to see how the risk-return characteristics of these different assets might have changed over time, rather than giving a one-shot look for the entire sample. This enables us to examine how risk-adjusted returns vary across these different periods.

By analysing diversified portfolio paired performances, the results confirm that having a combined portfolio of commodities and equities improves performance for different investment horizons. Specifically, we observe that in non-crisis periods 2001-2006 (and 2011-2017) it is either the equally weighted or optimally weighted portfolios that show the greatest performances. However, as we enter into crisis zones such as the Asian crisis of 1997-2000 and the global financial crisis and Eurozone debt crisis periods the risk-aversion behaviour of investors become prominent as the risk-minimizing portfolios record the highest performances.

Notes

1 The linear correlation and cointegration methods have, however, been criticized on many grounds that they may produce bias estimates due to the problems of heteroscedasticity, endogeneity, and omitted variable bias. Whilst there is great potential in the GARCH-type models in modelling asset returns behaviours, they also have the drawback of working with the assumption that return innovations are generally characterized by asymmetric multivariate normal or student-t distributions (Patton, 2006; Garcia and Tsafack, 2011). This assumption obviously is at odds with the empirics (Mensah and Alagidede, 2017) because the distribution of financial returns possesses fat-tails than those of the normal distributions and most financial returns exhibit non-linear dynamics and are usually asymmetric (Embrechts et al, 2002).

2 See CFTC Index Investment Data, *http:/www.cftc.gov/MarketReports/IndexInvestmentData/index.htm*

3 See Table 1 for the various demand and supply shocks that occurred.

4 Financialization is defined as a situation in which commodities prices are driven, not only by fundamental factors, but also by rising importance of financial elements, institutions and the speculative behaviour of investors in commodity markets (Falkowski, 2011).

5 Table not shown for brevity of space but available at any time upon request.

6 See also Pradhananga (2016).

7 Confidence intervals are based on fisher's result for usual caveat bivariate correlation.

8 Only one Panel of the appendix is shown for demonstration purposes due to brevity of space. The rest are available upon request.

9 This is supported by Beck et al (2009).

10 The one-month treasury bill rate is sourced from the website of the Federal Reserve Bank of St. Louis *https://research.stlouisfed.org/fred2/categories/116*

11 BCOM – Bloomberg Commodities Index. The index which has a base value of 100 as of 31 December 1990 and computed every 15 seconds is made up of 22 exchange-traded futures on physical commodities. The represented commodities are weighted to account for economic significance and market liquidity. Commodity weights are based on production and liquidity subject to weighting restrictions applied annually such that no related group of commodities constitute more than 33% of the index and no single commodity constitutes more than 15%.

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Appendix

Frequency risk-adjusted performance: Diversified portfolios

	D1		D2		D3		D4		D5		D6		S6	
PANEL C: 2001 - 2006														
	SF	GSR	SF	GSR	SF	GSR	SF	GSR	SF	GSR	SF	GSR	SF	GSR
Pf1 Nigeria-Oil	3.31	0	1.16	1.22	0.85	0.92	0.64	0.66	-0.35	-0.35	0.13	0.13	0.18	0.18
Pf 2 Nigeria Oil	3.20	0	1.71	1.67	0.78	0.79	0.55	0.58	-0.26	-0.25	0.27	0.28	0.18	0.18
Pf 3 Nigeria Oil	4.90	0	1.61	1.20	1.32	1.49	1.24	1.12	-0.27	-0.27	1.23	1.39	0.47	0.45
He Nigeria Oil	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	-Neg
Vlt Nigeria Oil	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Nigeria Energy	3.93	0	1.03	0.88	0.85	0.98	0.60	0.60	-0.36	-0.36	0.14	0.14	0.17	0.17
Pf 2 Nigeria Energy	2.79	0	1.71	1.67	0.78	0.79	0.55	0.58	-0.26	-0.25	0.27	0.28	0.18	0.18
Pf 3 Nigeria Energy	5.05	0	1.72	1.95	1.41	1.46	1.36	1.17	-0.19	-0.19	1.19	1.35	0.53	0.51
He Nigeria Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Nigeria Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1nigeria Agric	11.65	0	1.59	1.70	0.81	0.94	0.64	0.68	-0.45	-0.44	0.26	0.26	0.13	0.13
Pf 2 Nigeria Agric	2.62	0	1.71	1.67	0.78	0.79	0.55	0.58	-0.26	-0.25	0.27	0.28	0.18	0.18
Pf 3 Nigeria Agric	3.81	4.06	1.23	1.56	1.04	0.90	0.99	0.81	-0.47	-0.47	0.84	0.94	0.29	0.29
He Nigeria Agric	Neg	Neg	Neg	Neg	Neg	pos	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Nigeria Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Nigeria Pm	16.45	0	1.34	1.49	0.87	0.73	0.61	0.64	-0.36	-0.36	0.27	0.27	0.17	0.17
Pf 2 Nigeria Pm	2.40	0.88	1.71	1.67	0.78	0.79	0.55	0.58	-0.26	-0.25	0.27	0.28	0.18	0.18

Pf 3 Nigeria Pm	4.26	0	1.41	1.49	1.13	1.03	1.06	0.93	-0.42	-0.44	0.83	0.92	0.35	0.34
He Nigeria Pm	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	-Neg	Neg	Neg	Neg	Neg	Neg
Vlt Nigeria Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Bostwana Energy	2.43	3.04	1.04	0.94	0.94	0.96	0.70	0.68	-0.47	-0.49	0.21	0.21	0.18	0.18
Pf 2 Bostwana Energy	1.70	2.41	1.70	2.25	0.95	0.93	0.61	0.63	-0.43	-0.47	0.44	0.46	0.21	0.21
Pf 3 Bostwana Enrgy	3.52	3.63	1.19	1.58	0.98	1.05	0.93	1.00	-0.33	-0.33	0.83	0.93	0.33	0.33
He Bostwana Energy	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Bostwana Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Bostwana Beverage	2.54	3.13	1.09	1.30	1.05	0.79	0.59	0.54	-0.56	-0.58	0.39	0.40	0.15	0.15
Pf2 Bostwana Beverage	2.08	3.20	1.70	2.25	0.95	0.93	0.61	0.63	-0.43	-0.47	0.44	0.46	0.21	0.21
Pf3 Bostwana Beverage	3.36	3.33	1.15	1.32	0.96	0.91	0.93	0.89	-0.40	-0.41	0.93	1.06	0.31	0.30
He Bostwana Beverage	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Bostwana Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Bostwana Agric	2.10	3.14	1.39	1.44	0.90	0.85	0.66	0.67	-0.56	-0.60	0.36	0.37	0.14	0.14
Pf 2 Bostwana Agric	1.72	2.45	1.70	2.25	0.95	0.93	0.61	0.63	-0.43	-0.47	0.44	0.46	0.21	0.21
Pf3 Bostwana Agric	3.92	3.94	1.31	0.53	1.06	0.85	1.03	0.90	-0.38	-0.37	1.01	1.16	0.35	0.34
He Bostwana Agric	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Bostwana Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Bostwana Pm	2.00	2.80	1.28	1.74	0.96	0.79	0.67	0.69	-0.44	-0.46	0.33	0.33	0.17	0.17
Pf 2 Bostwana Pm	1.61	2.21	1.70	2.25	0.95	0.93	0.61	0.63	-0.43	-0.47	0.44	0.46	0.20	0.21

Pf 3 Bostwana Pm	4.16	4.08	1.39	1.09	1.13	1.27	1.11	1.35	-0.29	-0.29	0.96	1.09	0.41	0.39
He Bostwana Pm	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Bostrwana Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Tunisia Cotton	1.93	2.68	0.43	0.42	0.73	0.77	0.74	0.78	-0.61	-0.62	0.15	0.15	0.00	0.00
Pf2 Tunisia Cotton	1.37	0.81	0.48	0.49	0.63	0.69	0.46	0.53	-0.52	-0.46	0.31	0.32	0.03	0.03
Pf 3 Tunisia Cotton	4.12	1.47	1.27	1.35	1.00	0.85	0.94	0.92	-0.45	-0.45	0.84	0.94	0.30	0.29
He Tunisia Cotton	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Tunisia Cotton	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Tunisia Energy	3.56	3.42	0.55	0.57	0.077	0.77	0.64	0.64	-0.52	-0.52	0.12	0.12	0.08	0.08
Pf 2 Tunisia Energy	1.57	1.44	0.48	0.49	0.63	0.69	0.46	0.53	-0.52	-0.46	0.31	0.32	0.03	0.03
Pf3 Tunisia Energy	3.47	1.87	1.06	0.84	0.79	0.85	0.71	0.81	-0.49	-0.51	0.69	0.74	0.20	0.20
He Tunisia Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Tunisia Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Tunisia Beverage	1.66	1.32	0.55	0.51	0.86	0.73	0.49	0.51	-0.59	-0.55	0.29	0.29	0.05	0.05
Pf 2 Tunisia Beverage	1.61	2.02	0.48	0.49	0.63	0.69	0.46	0.53	-0.52	-0.46	0.31	0.32	0.04	0.04
Pf 3 Tunisia Beverage	4.32	2.77	1.38	1.20	1.10	1.06	1.07	0.89	-0.40	-0.44	0.88	1.00	0.35	0.34
He Tunisia Beverage	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Tunisia Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Tunisia Agric	2.21	1.69	0.72	0.75	0.72	0.70	0.57	0.64	-0.60	-0.59	0.24	0.24	0.04	0.04
Pf 2 Tunisia Agric	1.59	1.52	0.48	0.49	0.63	0.69	0.46	0.53	-0.52	-0.46	0.31	0.32	0.03	0.03
Pf 3 Tunisia Agric	4.14	3.51	1.33	1.38	1.06	1.23	1.01	1.06	-0.38	-0.39	0.98	1.12	0.35	0.34
He Tunisia Agric	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Tunisia Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Tunisia Pm	2.05	0	0.67	0.64	0.74	0.82	0.59	0.61	-0.48	-0.46	0.23	0.22	0.08	0.08
Pf2 Tunisia Pm	1.48	1.11	0.48	0.49	0.63	0.69	0.46	0.53	-0.52	-0.46	0.31	0.32	0.03	0.03
Pf 3 Tunisia Pm	4.40	4.54	1.42	1.71	1.16	1.42	1.17	1.36	-0.22	-0.22	1.04	1.18	0.45	0.43

He Tunisia Pm	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Tunisia Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Cote D'voire Cocoa	1.18	1.28	0.55	0.55	0.94	1.08	0.49	0.51	-0.38	-0.37	0.05	0.06	0.13	0.13
Pf 2 Cote D'voire Cocoa	2.94	4.68	0.66	0.66	0.61	0.68	0.51	0.54	-0.14	-0.14	0.02	0.02	0.17	0.17
Pf 3 Cote D'voire Cocoa	4.50	6.23	1.50	1.25	1.17	0.95	1.21	1.38	-0.36	-0.37	0.87	0.99	0.40	0.39
He Cote D'voire Cocoa	Neg	Neg	Neg	Neg	pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Cote D'voire Cocoa	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Cote D'voire Energy	3.28	4.65	0.61	0.57	0.76	0.77	0.60	0.65	-0.28	-0.27	-0.05	-0.05	0.15	0.15
Pf 2 Cote D'voire Energy	3.13	2.78	0.66	0.66	0.61	0.68	0.51	0.54	-0.14	-0.14	0.02	0.02	0.16	0.16
Pf 3 Cote D'voire Energy	3.99	0	1.28	0.61	0.96	0.90	0.84	0.83	-0.44	-0.44	1.04	1.18	0.28	0.28
He Cote D'voire Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	pos	Neg	Neg
Vlt Cote D'voire Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Cote D'voire Beverage	2.11	0.50	0.64	0.64	0.83	0.93	0.53	0.53	-0.34	-0.32	0.07	0.07	0.12	0.12
Pf2 Cote D'voire Beverage	4.48	6.84	0.66	0.66	0.61	0.68	0.51	0.54	-0.14	-0.14	0.02	0.02	0.16	0.17
Pf 3 Cote D'voire Beverage	4.76	6.50	1.58	1.22	1.26	1.51	1.35	1.48	-0.16	-0.17	0.96	1.10	0.52	0.49
He Cote D'voire Beverage	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Cote D'voire Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

Pf1 Cote D'voire Agric	2.44	3.06	0.85	0.88	0.70	0.78	0.60	0.64	-0.35	-0.35	0.04	0.04	0.11	0.11
Pf 2 Cote D'voire Agric	3.40	2.61	0.66	0.66	0.61	0.68	0.51	0.54	-0.14	-0.14	0.02	0.02	0.16	0.16
Pf3 Cote D'voire Agric	4.09	3.20	1.32	177	1.08	0.90	1.04	0.95	-0.36	-0.38	0.97	1.10	0.36	0.35
He Cote D'voire Agric	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Cote D'voire Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Cote D'voire Pm	2.18	2.68	0.76	0.81	0.77	0.88	0.59	0.62	-0.26	-0.26	0.09	0.09	0.15	0.15
Pf2 Cote D'voire Pm	2.73	3.24	0.66	0.66	0.61	0.68	0.51	0.54	-0.14	-0.14	0.02	0.02	0.16	0.16
Pf 3 Cote D'voire Pm	5.24	7.49	1.74	1.46	1.41	1.74	1.48	1.44	-0.06	-0.06	1.12	1.27	0.60	0.57
He Cote D'voire Pm	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Cote D'voire Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Ghana Oil	1.09	1.03	0.56	0.53	0.76	0.80	0.91	1.01	-0.52	-0.51	0.05	0.05	0.12	0.12
Pf2 Ghana Oil	2.04	2.52	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.09	0.09
Pf3 Ghana Oil	4.70	0	1.53	1.99	1.25	0.98	1.23	1.19	-0.39	-0.38	0.92	1.05	0.39	0.38
He Ghana Oil	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Ghana Oil	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Ghana Gold	2.60	2.30	1.09	1.07	0.76	0.83	0.84	1.03	-0.59	-0.60	0.10	0.10	0.11	0.11
Pf2 Ghana Gold	2.36	3.70	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.09	0.09
Pf3 Ghana Gold	3.92	0	1.27	1.32	1.03	1.18	0.92	0.90	-0.46	-0.48	0.93	1.06	0.30	0.29
He Ghana Gold	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Ghana Gold	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Ghana Cocoa	1.35	1.47	0.73	0.84	0.94	0.91	0.68	0.74	-0.71	-0.76	0.09	0.09	0.10	0.10
Pf 2 Ghana Cocoa	3.19	5.38	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.11	0.11
Pf 3 Ghana Cocoa	4.04	7.77	1.31	1.46	1.13	1.21	0.98	0.92	-0.39	-0.37	0.91	1.04	0.35	0.34

He Ghana Cocoa	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Ghana Cocoa	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Ghana Energy	7.51	0	0.85	0.58	0.76	0.81	0.79	0.90	-0.59	-0.60	-0.07	-0.07	0.11	0.11
Pf 2 Ghana Energy	2.99	3.33	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.10	0.10
Pf 3 Ghana Energy	4.58	0	1.51	1.72	1.23	1.14	1.11	1.08	-0.49	-0.51	0.87	0.98	0.34	0.33
He Ghana Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Ghana Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Ghana Beverage	2.58	2.75	0.90	0.72	0.83	0.94	0.77	0.89	-0.67	-0.72	0.11	0.11	0.09	0.09
Pf 2 Ghana Beverage	4.04	6.43	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.10	0.10
Pf 3 Ghana Beverage	3.67	6.81	1.18	1.30	0.98	1.09	0.88	0.72	-0.43	-0.43	0.93	1.05	0.29	0.29
He Ghana Beverage	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Ghana Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Ghana Agric	3.11	4.09	1.16	1.22	0.70	0.69	0.87	1.14	-0.66	-0.63	0.07	0.07	0.08	0.08
Pf 2 Ghana Agric	2.97	3.36	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.10	0.10
Pf3 Ghana Agric	4.14	0	1.35	1.19	1.09	1.27	1.04	1.14	-0.38	-0.35	0.93	1.06	0.35	0.34
He Ghana Agric	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Ghana Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Ghana Pm	2.86	2.86	1.07	1.17	0.76	0.83	0.85	1.03	-0.56	-0.56	0.12	0.12	0.12	0.12
Pf 2 Ghana Pm	2.56	4.05	1.20	1.57	0.62	0.62	0.90	1.19	-0.60	-0.58	0.07	0.07	0.10	0.10
Pf 3 Ghana Pm	3.99	0	1.30	1.40	1.06	1.21	0.96	0.94	-0.45	-0.46	0.94	1.06	0.31	0.30
He Ghana Pm	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Ghana Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Kenya Tea	2.93	3.48	1.57	0.94	0.61	0.58	0.95	1.01	-0.45	-0.47	0.57	0.58	0.14	0.14
Pf 2 Kenya Tea	1.86	1.63	1.44	1.50	0.45	0.48	1.07	1.16	-0.23	-0.23	0.55	0.57	0.24	0.24
Pf 3 Kenya Tea	3.69	0	1.18	1.50	0.93	0.97	0.83	0.88	-0.51	-0.54	0.84	0.94	0.24	0.24
He Kenya Tea	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Kenya Tea	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

Pf1 Kenya Energy	3.63	2.30	0.82	0.76	0.80	0.81	0.98	1.14	-0.36	-0.37	0.32	0.33	0.22	0.22
Pf 2 Kenya Energy	1.80	1.59	1.44	1.50	0.45	0.48	1.07	1.16	-0.23	-0.23	0.55	0.57	0.24	0.24
Pf 3 Kenya Energy	2.59	0	0.78	0.94	0.62	0.73	0.44	0.39	-0.67	-0.77	0.57	0.60	0.04	0.04
He Kenya Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Kenya Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Kenya Beverage	2.76	4.47	0.89	0.86	0.82	0.81	0.86	0.89	-0.42	-0.42	0.58	0.59	0.18	0.18
Pf 2 Kenya Beverage	1.86	1.71	1.44	1.50	0.45	0.48	1.07	1.16	-0.23	-0.23	0.55	0.57	0.24	0.24
Pf 3 Kenya Beverage	3.60	4.26	1.14	1.22	0.96	1.08	0.88	0.62	-0.51	-0.50	0.83	0.94	0.24	0.24
He Kenya Beverage	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Kenya Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Kenya Agric	3.19	3.90	1.25	1.14	0.67	0.72	0.96	1.05	-0.43	-0.41	0.45	0.46	0.17	0.17
Pf 2 Kenya Agric	1.74	1.60	1.44	1.50	0.45	0.48	1.07	1.16	1.30	1.41	0.55	0.57	0.23	0.24
Pf 3 Kenya Agric	3.82	5.34	1.23	1.42	1.01	0.86	0.95	1.12	-0.43	-0.44	0.92	1.04	0.30	0.30
He Kenya Agric	Neg	Pos	Neg	Neg	Neg	0	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Kenya Agric	Low	Low	Low	Low	Low	0	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Kenya Pm	3.44	3.98	1.12	1.13	0.72	0.77	0.96	1.04	-0.34	-0.34	0.37	0.38	0.20	0.20
Pf 2 Kenya Pm	1.65	1.62	1.44	1.50	0.45	0.48	1.07	1.16	-0.23	-0.23	0.55	0.57	0.23	0.23
Pf 3 Kenya Pm	4.12	0	1.36	1.46	1.12	1.26	1.08	0.67	-0.39	-0.36	0.83	0.92	0.36	0.34
He Kenya Pm	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Kenya Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 South Africa Gold	1.66	2.36	1.01	0.89	0.62	0.58	0.54	0.57	-0.41	-0.41	0.15	0.16	0.14	0.14
Pf 2 South Africa Gold	1.04	1.31	0.88	0.87	0.34	0.33	0.42	0.40	-0.27	-0.28	0.09	0.09	0.13	0.13
Pf 3 South Africa Gold	3.10	1.55	0.98	0.94	0.84	0.69	0.72	0.77	-0.62	-0.64	0.54	0.56	0.15	0.15

He South Africa Gold	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt South Africa Gold	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 South Africa Energy	2.15	1.75	0.82	0.87	0.68	0.62	0.57	0.53	-0.39	-0.39	0.00	0.00	0.14	0.15
Pf 2 South Africa Energy	1.13	1.39	0.88	0.87	0.34	0.33	0.42	0.40	-0.27	-0.28	0.09	0.09	0.14	0.14
Pf 3 South Africa Energy	2.40	3.69	0.73	0.85	0.69	0.82	0.77	0.79	-0.59	-0.61	0.58	0.61	0.11	0.11
He South Africa Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt South Africa Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 South Africa Beverage	2.15	1.17	0.83	0.76	0.67	0.64	0.48	0.46	-0.46	-0.47	0.16	0.16	0.12	0.12
Pf 2 South Africa Beverage	1.33	1.47	0.88	0.87	0.34	0.33	0.42	0.40	-0.27	-0.28	0.09	0.09	0.14	0.14
Pf3 South Africa Beverage	3.36	3.90	1.11	1.23	0.91	1.12	0.93	0.98	-0.43	-0.44	0.68	0.74	0.27	0.27
He South Africa Beverage	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt South Africa Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 South Africa Agric	1.78	2.41	1.02	1.04	0.56	0.52	0.52	0.48	-0.47	-0.50	0.11	0.11	0.10	0.10
Pf2 South Africa Agric	1.15	1.41	0.88	0.87	0.34	0.33	0.42	0.40	-0.27	-0.28	0.09	0.09	0.14	0.14
Pf 3 South Africa Agric	3.76	5.21	1.22	0.94	0.98	0.82	0.94	0.95	-0.46	-0.48	0.80	0.89	0.28	0.28
He South Africa Agric	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg

Vlt South Africa Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 South Africa Pm	2.15	1.17	0.83	0.76	0.67	0.64	0.48	0.46	-0.46	-0.47	0.16	0.16	0.12	0.12
Pf2 South Africa Pm	1.33	1.47	0.88	0.87	0.34	0.33	0.42	0.40	-0.27	-0.28	0.09	0.09	0.14	0.14
Pf 3 South Africa Pm	3.36	3.90	1.11	1.23	0.91	1.12	0.93	0.98	-0.43	-0.44	0.68	0.74	0.27	0.27
He South Africa Pm	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt South Africa Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Egypt Cotton	0.76	0.76	0.30	0.30	0.70	0.81	0.99	0.99	-0.33	-0.33	0.24	0.24	0.16	0.16
Pf 2 Egypt Cotton	0.91	0.89	0.25	0.26	0.63	0.64	0.81	0.87	0.00	0.00	0.38	0.38	0.29	0.30
Pf 3 Egypt Cotton	3.93	5.86	1.22	1.48	0.86	0.92	0.69	0.70	-0.58	-0.59	0.93	1.06	0.18	0.18
He Egypt Cotton	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Egypt Cotton	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Egypt Energy	1.24	1.07	0.44	0.44	0.75	0.74	0.85	0.86	-0.21	-0.21	0.22	0.22	0.25	0.26
Pf2 Egypt Energy	0.97	0.92	0.25	0.26	0.63	0.64	0.81	0.87	0.00	0.00	0.38	0.38	0.29	0.30
Pf 3 Egypt Energy	3.05	5.15	0.97	0.68	0.62	0.67	0.39	0.40	-0.83	-0.76	0.88	0.99	-0.01	-0.01
He Egypt Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos
Vlt Egypt Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Egypt Beverage	1.12	1.36	0.45	0.48	0.89	0.90	0.77	0.76	-0.27	-0.26	0.41	0.42	0.21	0.21
Pf 2 Egypt Beverage	1.20	0.78	0.25	0.26	0.63	0.64	0.81	0.87	0.00	0.00	0.38	0.38	0.30	0.31
Pf 3 Egypt Beverage	3.83	0	1.28	1.16	1.04	0.90	1.01	1.19	-0.37	-0.38	0.91	1.03	0.35	0.34
He Egypt Beverage	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Egypt Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf1 Egypt Agric	1.06	1.11	0.62	0.59	0.74	0.73	0.85	0.87	-0.29	-0.28	0.34	0.34	0.20	0.20

Pf 2 Egypt Agric	1.03	0.91	0.25	0.26	0.63	0.64	0.81	0.87	0.00	0.00	0.38	0.38	0.30	0.30
Pf3 Egypt Agric	3.62	5.70	1.15	1.37	0.92	1.02	0.81	0.93	-0.49	-0.49	0.94	1.07	0.24	0.24
He Egypt Agric	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Egypt Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Egypt Pm	1.01	1.05	0.57	0.59	0.81	0.75	0.88	0.91	-0.21	-0.20	0.36	0.37	0.24	0.24
Pf 2 Egypt Pm	0.96	0.91	0.25	0.26	0.63	0.64	0.81	0.87	0.00	0.00	0.38	0.38	0.29	0.30
Pf 3 Egypt Pm	3.47	5.38	1.09	1.01	0.87	1.01	0.77	0.88	-0.59	-0.60	0.74	0.82	0.19	0.18
He Egypt Pm	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg
Vlt Egypt Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Morroco Cotton	1.71	1.10	0.59	0.50	0.64	0.70	0.54	0.57	-0.60	-0.60	0.26	0.27	0.01	0.01
Pf 2 Morroco Cotton	1.64	1.47	0.75	0.63	0.48	0.54	0.23	0.24	-0.45	-0.47	0.45	0.47	0.06	0.06
Pf 3 Morroco Cotton	3.94	0	1.28	1.35	0.99	0.93	0.91	0.90	-0.43	-0.44	1.04	1.19	0.31	0.30
He Morroco Cotton	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Morroco Cotton	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Morroco Energy	1.96	2.02	0.68	0.64	0.76	0.75	0.46	0.45	-0.50	-0.51	0.23	0.23	0.09	0.09
Pf 2 Morroco Energy	1.94	1.37	0.75	0.63	0.48	0.54	0.23	0.24	-0.45	-0.47	0.45	0.47	0.06	0.06
Pf 3 Morroco Energy	3.72	0	1.18	0.59	0.92	1.05	0.98	0.97	-0.50	-0.49	0.95	1.08	0.26	0.26
He Morroco Energy	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Morroco Energy	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Morroco Beverage	3.60	6.03	0.70	0.52	0.80	0.92	0.36	0.36	-0.57	-0.61	0.41	0.42	0.06	0.06
Pf 2 Morroco Beverage	2.73	0	0.75	0.63	0.48	0.54	0.23	0.24	-0.45	-0.47	0.45	0.47	0.07	0.07

Pf 3 Morroco Beverage	4.18	5.47	1.41	1.22	1.12	1.48	1.14	1.07	-0.30	-0.31	1.12	1.27	0.42	0.40
He Morroco Beverage	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Morroco Beverage	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Morroco Agric	2.40	2.47	0.92	0.80	0.65	0.74	0.42	0.46	-0.59	-0.62	0.44	0.45	0.05	0.05
Pf 2 Morroco Agric	2.09	1.19	0.75	0.63	0.48	0.54	0.23	0.24	-0.45	-0.47	0.45	0.47	0.06	0.06
Pf 3 Morroco Agric	3.92	0	1.28	1.04	0.99	1.13	0.94	0.82	-0.46	-0.41	0.94	1.06	0.30	0.29
He Morroco Agric	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg	Neg	Neg
Vlt Morroco Agric	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Pf 1 Morroco Pm	2.12	2.35	0.85	0.65	0.73	0.90	0.44	0.46	-0.48	-0.49	0.42	0.43	0.09	0.09
Pf 2 Morroco Pm	1.81	1.45	0.75	0.63	0.48	0.54	0.23	0.24	-0.45	-0.47	0.45	0.47	0.06	0.06
Pf 3 Morroco Pm	3.55	4.86	1.12	0.98	0.91	0.83	0.84	0.76	-0.57	-0.55	0.74	0.81	0.21	0.21
He Morroco Pm	Neg	pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Pos	Neg	Neg	Neg	Neg
Vlt Morroco Pm	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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