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Examining evidence of 'shift-contagion' in African stock markets: A CoVaR-copula approach

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Abstract

This paper examines for the first time contagion to African stock markets with particular attention to the quantification of, and testing for the impact of (extreme) downside movements in foreign exchange and developed stock markets on the (extreme) downside risks in Africa stock markets. Using data of weekly periodicity, the empirical analysis captured the pre, during (both turmoil and acute), and post periods of the 2007–2009 global financial crisis. We analyzed contagion by comparing (extreme) downside cumulative mean distribution conditional value-at-risk (CoVaR) values for African stock markets for successive periods and tested for significance of contagion using the Kolmogorov–Smirnoff (KS) bootstrap technique. We used the KS statistic to test the hypothesis of equality or no systemic impact between the conditional African stock market return quantiles (for different successive sub-samples). CoVaR values are computed from four copula specifications — *Gaussian, Student-t, Gumbel and Rotated Gumbel.* By situating the empirical analysis within the shift-contagion thesis, we found evidence of contagion from some exchange rate and developed equity markets to African stocks only in the acute and the post-crisis periods. The findings are consistent with the view that global shocks propagation to developing markets may stagger during crisis and intensify post-crisis. A practical implication from the results is that given the relatively scarce resources and levels of technological know-how available to African governments, efforts to wean the continent's equity markets from adverse effects of global market crashes should be geared towards plans and programmes to mitigate the shocks not at the early stages but latter stages, where the effects to Africa could be pronouncedly felt.

JEL classification: G10; G15; F30; F31

Keywords: Shift-contagion; Decoupling; CoVaR-copula; Africa; Exchange rates; Stock markets

1. Introduction

The financial crisis of 2007–2009 led to crashes in most equity markets across the globe. Not only did the crisis spark downturns in equity markets but also most foreign exchange markets of several developed and emerging markets witnessed dramatic movements (Celik, 2012). Contagion theorists believe that crashes in developed markets will obviously trigger tremors in emerging or developing markets. However, many analysts are of the opinion that emerging/developing markets will be insulated from the effects of turmoil in developed markets. The argument behind this belief is the touted "decoupling theory", which assumes that following the 2007–2009 crisis, the developed economy (e.g. U.S.) is no longer the driver of world economic growth but the developing and emerging market economies. Debates about Africa's decoupling have largely centered on the global financial crisis (GFC) of 2007–2009. Reasons for believing Africa's decoupling from developed and global shocks have mainly been attributed to the continent's relatively less integrated economy and markets.

Contagion rallies the correlation of assets to unity, and lessens the rewards of portfolio diversification (Gulko, 2002). This view holds that crashes in developed markets or global economies lead to sell-offs in markets around the globe. This, the decoupling theory contradicts. The decoupling phenomenon holds that crashes in developed markets/economies do not necessarily result in losses in emerging markets; and that, emerging markets provide active diversification during GFCs. However, most studies (e.g. Pula and Peltonen, 2009; Dooley and Hutchison,

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2009) found no consistent evidence in endorsement of the decoupling view for emerging BRIC countries. Another implication of the decoupling theory is that the correlation of returns of emerging and developed equity markets, foreign exchange markets, as well as global commodities markets shifts from positive to negative in crisis periods. This suggests that returns from Africa and the developed markets, their currency markets, and global commodities markets are not jointly normal, annulling the Markowitz constant parameter mean-variance model. "The joint non-normality of returns has also been questioned in light of the market contagion that occurs during financial crisis" (Gulko, 2002: p. 64). However, critics of the decoupling phenomenon contend that to believe in the existence of decoupling is nothing but suggesting that the global economy is disconnected (Fitz-Gerald, 2010). Considering the uncertainty surrounding the joint non-normality assumption by the decoupling theory, it would be useful to test African markets decoupling from global shocks in order to ascertain whether African stocks can provide hedging and diversification avenues for investors seeking to diversify their portfolios pre, during, and after global crisis. Evidence in favour of shocks propagation would mean contagion and the absence of decoupling.

The case of Africa is notable to investigate due to the continent's recent strengthening of economic links with developed countries (see Sugimoto et al., 2014). Further, with open market policies to international investors and increased efforts at overcoming barriers to international trade, investments in African economies have increasingly become attractive to foreign investors. Thus, making studies on contagion to African economies an interesting arena for both local and international investors. Unlike developed markets, studies exploring contagion effects to African equity markets appear very scanty. Daryl and Biekpe (2002) find evidence of contagion from the 1997 Asian crisis to South Africa, Egypt, Namibia, and Morocco. Further, Louis et al. (2009) indicate that the financial markets in Africa were affected by the contagious effects of the GFC; and that, the effects were enlarged by over-valued equities and inadequate diversification of same in the pre-crisis period. However, Forbes and Rigobon (2002) find no sign of contagion to South Africa. The view of Giovannetti and Velucchi (2013) is that while Kenya and Tunisia are "net creators" of volatility spill-overs from global markets to Africa; South Africa turns out to be a "net absorber". In a related setting, Alagidede (2008) reveal that apart from South Africa, African markets respond to domestic rather than global information.[1]

The aim of this paper is to examine whether (extreme) downturns in foreign exchange and developed equity markets spread to African stock markets? We investigate this aim within the framework of the Forbes and Rigobon (2002) shift-contagion theory (see details and distinction in subsequent sections). Of particular significance is the test of the theoretical validity of the shift-contagion and decoupling theories within Africa. If evidence is established against the shift-contagion theory it will also mean that African stocks were decoupled from effects of the GFC.

The paper makes the following contributions to recent literature on contagion: first, extant studies have mainly examined contagion between only stock markets (example, Forbes and Rigobon, 2002; Daryl and Biekpe, 2002; Naoui et al., 2010; Hwang et al., 2010). This paper, among others, examines contagion between stocks and foreign exchange markets. Including foreign exchanges will enable us to ascertain whether foreign currency price risk command significant premium in African stock markets. Second, to the best of our knowledge, none of the studies on contagion has examined tail effects with particular attention to the quantification of, and testing for the impact of downside movements in foreign exchange and developed stock markets on the (extreme) downside risks in emerging stock markets. The paper by Reboredo et al. (2016) is however notable, even though it focuses on only extreme spillovers between stocks and currencies. The paucity of related studies on Africa is very disturbing. Meanwhile such downside contagion analysis is important for investors seeking to protect a diversified portfolio against adverse effects of extreme market movements. Further, our examination of contagion captures different phases of the GFC period — pre, phase I, phase II, and post.

The rest of the paper is structured as follows: Section 2 presents theoretical literature. Section 3 outlines data and research design. Sections 4 and 5 present results and conclusion, respectively.

2. Theoretical sketch — *contagion*

In spite of its popularity, ragging contentions abound on the precise definition of contagion in the financial economics literature. However, results of empirical findings on contagion would be meaningless unless theoretical and empirically relevant and better comprehension of the definition of contagion between and among markets is established. Common theoretical definitions of contagion in the literature are primarily based on the "pure" and "fundamental-based" concepts. The former asserts that contagion is said to occur when shock is transmitted from one country/market to another, without any idiosyncratic disorders and factors. On the other hand, the fundamental-based theory defines contagion as having occurred when shock transmission is propagated from one country/market to the other through the real sector (such as trade linkages or interdependence) or macroeconomic factors. If for instance, returns (r) on a country's (say i) equity markets are dependent on some set of economic factors (f) and a residual component or stochastic term, ε_i:

$$r_i = \delta_i + \lambda_i f + \varepsilon_i \tag{1}$$

then, on the assumption that the residual component (ε_i) in Eq. (1) shows significant correlations across markets, contagion may be deemed to have occurred, according to the fundamental-based theory (see Pritsker, 2000; Bekaert et al., 2005). Despite the dominance of the fundamental-based theory over the pure one, the former has come under severe criticisms. Pritsker (2000) argues that, the fundamental-based definition is flawed on two

[1] See also Boako and Alagidede (2017).

grounds. First, since the right set of fundamentals might not be accounted for, establishing contagion can always be questionable. The second identified shortfall is the cross-market hedging — see Pritsker (2000).

In their attempt to overcome shortfalls inherent in the above theoretical definitions, Forbes and Rigobon (2002), hereafter referred to as FR proposed the "*shift-contagion*" theory — *significant surges in cross-market nexus during crisis.*[2] In case only linkages occur with no significant increases in cross-market linkages, they describe the event as *interdependence*. Their choice of the term "*shift-contagion*" other than contagion is exemplified in its ability to show that contagion arises from a shift in cross-market linkages, and also remains open on the manner in which the shift occurs. Their view is supported by Celik (2012) who examined the existence of financial contagion between foreign exchange markets of several emerging and developed countries during the U.S. subprime crisis and observed that unconditional correlations increase in crisis periods relative to the pre-crises period — see also, King and Wadhawani (1990). In spite of what FR describes as the strengths of their shift-contagion theory, proponents of the pure contagion theory disagree and point out that, in so far as there is transmission of shocks from one market/country to the other, contagion occurs; it does not matter whether or not there is significant change in cross-market linkages.

A more recent advancement to the theoretical and empirical definition of contagion is that proposed by Bekaert et al. (2014). The authors define contagion based on existing fundamentals as "the co-movement in excess of that implied by the factor model" (Bekaert et al., 2014, p. 2598). Based on a benchmark factor model, called the "interdependence model",[3] Bekaert et al. (2014) proposed four distinct types of contagion. They proposed that contagion emanating from the US or global financial sector be called "*US contagion" or "Global contagion*" respectively. Further, they describe increases in the joint movement of domestic portfolios during crisis relative to the factor models predictions as "*Domestic contagion"*; and finally, correlation of excess returns across equities uncorrelated to the factor model in crisis periods as "*Residual contagion*". When tested empirically, the authors retreated on some of the propositions on the types of contagion they had proposed. First, they strongly reject the interdependence model statistically. Additionally, while the authors establish significant statistical but little economic proof in favour of the US and global contagion, they find strong evidence supporting the domestic contagion. On account of the limited success rate (about 25%) of the proposition by Bekaert et al. (2014) in their own empirical test, the immediate acceptance of their propositions remains an empirical question that only time can tell.

On the basis of the above, the inclination of this paper is to agree with FR's shift-contagion theory, albeit with modification. We thus, argue for extension in favour of 'delayed shift contagion' — *thus increases in shock propagation post-crisis* (see details in Sub-section 4.2). Our empirical examination thus tests the validity of the 'shift-contagion' in Africa; and based on the outcomes make inferences for the existence of decoupling theory and/or 'delayed-shift contagion' theory. As a primer to our empirical test to establish evidence or otherwise of delayed shift contagion, we wish to bring to the fore some existing facts in support of the need to extend the definition from *shift-contagion* to *delayed shift-contagion*. First, using a standard factor model representation in an international CAPM framework that allows for spillover effects outside crisis periods, Dungey and Gajurel (2015) found substantially more evidence of US banking volatility spillovers to about 60% of the sample in non-crisis periods relative to the 2007–2009 crisis period. When crisis is disaggregated into phases, the authors report that volatility contagion is limited in the phase one and more prevalent in phase two. The authors' further report that evidence of systematic contagion (potential structural changes in global systematic risk exposure) is strongly skewed towards developing markets. Thus, the belief that global shocks propagation to developing markets may stagger during crisis and intensify post-crisis is not far from reality.

3. Data and empirical strategies

3.1. Data

We empirically examine contagion using weekly data from 10th January, 2003 to 12th February, 2016 with the free float-adjusted market capitalization Morgan Stanley Capital International (MSCI) indices of a set of six (6) African stock markets (namely, Kenya, South Africa, Morocco, Nigeria, Botswana, and Egypt), the Euro (EUR) and United States of America dollars (USD) foreign exchange rates against domestic African currencies,[4] as well as four developed equity markets (namely, Asia-excluding Japan (Asia-ex. J), FTSE 100, S&P500, EUSTXX50). All sampled African markets have economies that are opened to foreign capital flows and have taken the path of reducing foreign exchange and capital controls; and thus becoming highly relevant in international investor portfolios. The choice of these (African) markets is based on data availability and their relative verve in the continent. Put together, the selected markets constitute the largest markets and could therefore proxy for stock markets movements in Africa.

Although U.S remains the main origination point for the 2007–2009 financial crises, and thus, our main epicenter for examining contagion, we include some markets from Asia (Asia-ex. J) and Europe (EUSTXX50 and FTSE100). The idea is to examine whether shocks propagation from these markets could

[2] The understanding of the underlying orientation of this theory is a focus on the period in which the shock occurs (i.e. crisis periods). For instance, in analyzing empirically the Asia crisis in 2002, FR considered the month just after the fall of the Hang Seng stock market that occurred on October 17, 1997.

[3] They describe the interdependence model as the propagation of shocks proportional to the factor exposures in the tranquil period.

[4] The following domestic currencies against the EUR and USD are used: South Africa (Rand), Egypt (Pound), Kenya (Shilling), Nigeria (Naira), Botswana (Pula), and Morocco (Dirham).

spillover to Africa in tranquil or crisis periods of the GFC. If for instance, spillovers could not occur during the tranquil periods but occurred during the crisis, it may be construed that the markets in Asia and Europe acted as conduits for the propagation of U.S crisis to African markets or they propagated their own shocks, particularly in the case of EUSTXX50 and FTSE100 since the European debt crisis immediately followed the GFC in the second phase.[5] Because the considered markets are drawn from countries with different time zones they could potentially impact the data. However, the use of weekly instead of daily data erodes any potential effects arising out of asynchronous trading.

We use the EUR and USD as the foreign exchange rate pairs against the domestic currencies because they virtually dominate most commercial and financial transactions in these economies. In fact, Bekaert and Harvey (2014) recommend for the inclusion of new sub-segments such as currencies and bonds in related studies. Whilst we recognize that the GFC is largely an equity and banking crisis instead of a currency crisis, we are equally conscious of the fact that the US equity market may have simultaneously affected Forex markets and other equity markets, hence the inclusion of currencies and other global equity markets other than the U.S equity market (S&P500). All currencies are computed into quantities in the foreign currencies (EUR and USD) per the prevailing domestic currency rates similar to Reboredo and Ugolini (2015). Thus, an increase (decrease) in the exchange rates signifies a quantum of appreciation (depreciation) of the value of the local (African) currency. Similarly, the stock market datasets (Africa and developed) are expressed in USD for ease of comparison, a practice that has become ubiquitous in empirical studies of international financial markets — see for example, Pukthuanthong and Roll (2009) and Reboredo et al. (2016). Except Botswana (which is sourced from DataStream), all other data are gleaned from Bloomberg and analyzed with their returns computed as the logarithmic difference between two consecutive series.

To examine contagion around the 2007–2009 global financial crisis (GFC), we disaggregate the dataset into pre-, during-, and post-crisis periods — details to be outlined in subsequent sections.

3.2. Estimating contagion with CoVaR-copula

We estimate contagion through downside spillovers from foreign exchange and developed equity markets to stock markets in Africa using downside conditional value-at-risk (CoVaR). We use CoVaR instead of value-at-risk (VaR) because, the potency of VaR in calibrating risk has been challenged by most recent studies on account that it is not sub-additive (Artzner et al., 1999)[6]; meaning the VaR of a combined portfolio can be larger than the sum of the VaRs of its components. Further, VaR does not capture the risk reduction attributes of diversification. VaR also fails to take into account how much risk is propagated from a single exposure to the economy-wide system (i.e. lacks the strength to measure systemic risk)[7] when the entire system is under stress.

To examine contagion from foreign exchange and developed equity markets to African stock markets, we consider the impact of financial distress in foreign exchange and developed equity markets on African stock markets — *that is conditional VaR*. As outlined in the systemic risk literature, risk spillover is linked to the spread/transmission of failures from one market to another. To this end, we use the conditional value-at-risk (CoVaR) as populated by Adrian and Brunnermeier (2011). The CoVaR model is specified as follows:

Let y_t^s denote returns for the African stock markets and y_t^e be the returns for either the foreign exchange rates or developed stock markets, all at time t. CoVaR for the African stock returns for a confidence level of $(1-\beta)$ can be formally defined as the β-quantile of the conditional distribution of y_t^s as:

$$Pr\left(y_t^s \leq CoVaR_{\beta,t}^{s|e} | y_t^e \leq CoVaR_{\alpha,t}^e\right) = \beta \tag{2}$$

where, $CoVaR_{\alpha,t}^e$ is the α-quantile CoVaR of the foreign exchange rate (FX) or developed stock market (DSM) distribution that quantifies the maximum loss that may be experienced by the FX or DSM for a confidence level of $1-\alpha$ at time t.[8] Alternatively, we could estimate the systemic impact of the African stock markets on the FX and DSM by computing the CoVaR for the FX and DSM instead of the stock market, as in Eqs. (2) and (4). Computing the CoVaR involves the determination of the quantile of a conditional distribution, or, better still, of an unconditional bivariate distribution upon expressing Eq. (2) as:

$$\beta = \frac{Pr\left[y_t^s \leq CoVaR_{\beta,t}^{s|e}, y_t^e \leq CoVaR_{\alpha,t}^e\right]}{Pr\left[y_t^e \leq CoVaR_{\alpha,t}^e\right]} \tag{3}$$

Given that $Pr\left(y_t^e \leq CoVar_{\alpha,t}^e\right) = \alpha$, the CoVaR in Eq. (3) can be re-written as:

$$Pr\left(y_t^s \leq CoVaR_{\beta,t}^{s|e}, y_t^e \leq CoVaR_{\alpha,t}^e\right) = \alpha\beta \tag{4}$$

We use copulas to compute the CoVaR. In all, four copula specifications namely — *Gaussian, Student-t, Gumbel, and rotated-Gumbel* are used in both the static and time varying framework. Detailed information on the copula formulation can be obtained from Joe (1997), Nelsen (2006), and Reboredo et al. (2016).[9] Table 1 shows the functional forms and properties of the four copula specifications. Their dependence parameters are briefly presented below;

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[5] This, should however not be taking as a formal test for transmission channels. We may recommend further studies to formally examine the channels of such transmission.

[6] A measure of risk say, σ () is considered sub-additive, if, for any two functional assets P and Q, $\sigma(P+Q)$ is not greater than $\sigma(P)+\sigma(Q)$. Thus, sub-additivity is: $\sigma(P+Q) \leq \sigma(P)+\sigma(Q)$, for any risks of P and Q.

[7] Systemic risk may be defined as the collapse of a whole market where the failure of an idiosyncratic distress triggers a cascading failure of the entire system, as opposed to risk that is associated with only one individual entity, or group of entities, or a component of the system – Sheu and Cheng (2012).

[8] $Pr\left(y_t^e \leq Var_{\alpha,t}^e\right) = \alpha$

[9] We do not specify individual copula models for bivariate dependence since that is not the focus of this paper.

Table 1
Copula specifications.

Copula	Distribution	Parameter Space	Independence	Lower tail dep	Upper tail dep
Gaussian	$C_N(u, v; \rho) = \Phi_\rho(\Phi^{-1}(u), \Phi^{-1}(v))$	$\rho \in (-1, 1)$	$\rho = 0$	0	0
Student-*t*	$C_T(u, v; \rho, d) = T_{d,\rho}(t_d^{-1}(u), t_d^{-1}(v))$	$\rho \in (-1, 1)$ $d \in (2, \infty)$	$\rho = 0$	$\vartheta T(\rho, d)$	$\vartheta T(\rho, d)$
Gumbel	$C_G(u, v; \delta) = \exp\{-[(-\ln(u))^\delta + (-\ln(v))^\delta]^{1/\delta}\}$	$\delta \in (1, \infty)$	$\delta = 1$	0	$2 - 2^{1/\delta}$
Rotated Gumbel	$C_{RC}(u, v; \delta) = u + v - 1 + C_G(1 - u, 1 - v; \delta)$	$\delta \in (1, \infty)$	$\delta = 1$	$2 - 2^{1/\delta}$	0

Notes: The column titled "Independence" shows the parameter values that lead to independence copula. $_u$ and $_v$ denote the cumulative density functions of the standardized residuals from the marginal models and $0 \le u, v \le 1$. Φ_ρ is the bivariate cumulative distribution of the standard normal with correlation coefficient ρ and Φ^{-1} is the inverse function of the univariate normal distribution. $T_{d,\rho}$ is the bivariate student's t distribution with correlation coefficient ρ and degree of d, which captures the extent of symmetric extreme dependence; t^{-1} is the inverse function of the univariate Student's t distribution. δ denotes the parameters for the Gumbel and rotated Gumbel copulas.

1. The *Gaussian copula* allows for equal degrees of positive and negative dependence but does not allow for tail dependence $\left(\tau^U = \tau^L = 0\right)$. It is defined by $C_N(u, v; \rho) = \Phi_\rho(\Phi^{-1}(u), \Phi^{-1}(v))$, where Φ is the bivariate standard normal cumulative distribution function with correlation ρ between X and Y, and where $\Phi^{-1}(u)$ and $\Phi^{-1}(v)$ are standard normal quantile functions. A good feature of this copula is that the dependence parameter is the Pearson's correlation coefficient with the relation, $-1 \le \rho \le 1$.
2. The *Student's-t copula* assumes average dependence for both lower and upper tails of the joint distribution. It is given by $C_T(u, v; \rho, d) = T_{d,\rho}(t_d^{-1}(u), t_d^{-1}(v))$, where T is the bivariate *student-t* cumulative distribution function (CDF) with degree-of-freedom parameter d and correlation ρ where $t_d^{-1}(u)$ and $t_d^{-1}(v)$ are the quantile functions of the univariate student-t distribution with degree-of-freedom parameter, d.
3. The *Gumbel copula* is an asymmetric copula with higher probability concentrated in the right (upper) tail. It is given by $C_G(u, v; \delta) = \exp\{-[(-\ln(u))^\delta + (-\ln(v))^\delta]^{1/\delta}\}$. The parameter δ controls the dependence between the variables. A $\delta = 1$ means independence and a $\delta \to +\infty$ imply perfect dependence. The co-efficient of the upper tail dependence is defined by $\tau^U = \left(2 - 2^{1/\delta}\right)$.
4. The *rotated Gumbel copula* measures lower (left) tail dependence with the parameter $\delta \in [1, \infty]$ and takes a value of 1 in the case of independence. The lower tail dependence then becomes, $\tau^L = \left(2 - 2^{1/\delta}\right)$.

To obtain the CoVaR therefore, we express Eq. (4) in terms of the joint distribution function of y_t^s and y_t^e, $F_{s,e}$ as:

$$F_{s,e}\left(y_t^s, y_t^e\right) = C\left(u_s, u_e\right), \tag{5}$$

where $C(.,.)$ is a copula function,[10] $u_s = F_s\left(y_t^s\right)$ and $u_e = F_e\left(y_t^e\right)$, and F_s, F_e are the marginal distribution functions of y_t^s and y_t^e, respectively. Consequently, Eq. (3) can be expressed in terms of copulas as:

$$C\left(F_s\left(CoVaR_{\beta,t}^{s|e}\right),\ F_e\left(CoVaR_{\alpha,t}^{e}\right)\right) = \alpha\beta \tag{6}$$

$$1 - F_s\left(CoVaR_{\beta,t}^{s}\right) - F_e\left(CoVaR_{1-\alpha,t}^{e}\right) + C\left(F_s\left(CoVaR_{\beta,t}^{s}\right).F_e\left(CoVaR_{1-\alpha,t}^{e}\right)\right) = \alpha\beta \tag{7}$$

We can now compute the CoVaR from Eqs. (6) and (7) using a two-step approach (Reboredo and Ugolini, 2015; Reboredo et al., 2016).

i. Given that $C(u_s, u_e) = \alpha\beta$, and $\alpha,\ \beta,\ and\, u_e$ are given and that $u_e = \alpha$ from the specification of the copula function, we can determine the value of $u_s = F_s\left(CoVaR_{\beta,t}^{s|e}\right)$.
ii. With u we can derive CoVaR as the quantile of the distribution of y_t^s, with a cumulative probability equal to u, by inverting the marginal distribution function of y_t^s : $\mathrm{CoVa}R_{\beta,t}^{s|e} = F_s^{-1}(u_s)$.

The significance of the systemic spillover is tested by comparing the cumulative distribution for CoVaR $\left(CoVaR_{\beta,t}^{s}\right)$ of the African stock using the Kolmogorov-Smirnoff (KS) bootstrap technique by Abadie (2002) to compare CoVaR values. We use the KS statistic to test the hypothesis of equality or no systemic impact between the conditional African stock market return quantiles (for different successive sub-samples), as follows:

$$H_0 : CoVaR_q = CoVaR_j$$

$$H_1 : CoVaR_q < CoVaR_j$$

where, j and q are respectively, preceding and successive periods.

The K–S estimates the difference between two cumulative quantile functions relying on the empirical distribution function

[10] We use the best fit (optimal) copula that minimizes (maximizes) the Alkaike information criterion — AIC (log-likelihood) of each pair of the bivariate relationship.

but without considering any underlying distribution function (Reboredo et al., 2016). It is represented mathematically as:

$$KS_{mn} = \left(\frac{mn}{m+n}\right)^{\frac{1}{2}} \sup_x |F_m(x) - G_n(x)| \tag{8}$$

where $F_m(x)$ and $G_n(x)$ respectively, denote the cumulative expected conditional value-at-risk (CoVaR) quantile distribution functions for two successive periods (e.g. pre-crisis and Phase I), in that order; and n and m denote the size of the two samples.

4. Empirical analysis

4.1. Descriptive statistics

Descriptive statistics of all markets for the full sample period are shown in Table 2. In Panel A it is observed that the mean values of both African and developed stock markets were substantially small. The standard deviations of markets also show marked differences giving indication of volatility dispersion. Apart from Kenya, all other series have negative skewness. The kurtosis figures are large with fat-tails distribution. This casts doubt about the normality of the series; evidence of which is supported by the Jacque–Bera statistics. Both the Ljung–Box and Breusch–Godfrey Lagrange multiplier (LM) statistics at 20 lags indicate the existence of serial correlation in most of the markets. Panels B and C respectively report the summary measures for the USD and EUR against the domestic currencies. Similar to results in Panel A, returns and standard deviations averaged close to zero. Skewness was mainly positive for the EUR (except Kenya and Morocco) and USD (except Kenya). Both exchange rates display fat-tails, with consequential non-normality of returns distributions. Additionally, evidence of serial correlation is found for most of the exchange rate pairs as reported by the Ljung–Box and Breusch–Godfrey Lagrange multiplier (LM) statistics at 20 lags. The evidence of non-normality of the series is corroborated by the *qq* plots in Fig. 1. Such evidence against the normality assumption, especially at the tails of the *qq* plots makes it appropriate in considering contagion at the extreme (downside) of the distributions.

4.2. Analysing evidences of 'shift-contagion' in African stock markets?

It is instructive to note that the "shift-contagion" theory obviously considers positive changes in the cross-market correlations only during the life-span of crisis. This view suggests that transmission of shocks can occur only when crisis are known to be in existence. Meanwhile, the transmission mechanism of shocks may not always be direct, and that, intercepted shocks or shocks that pass through longer channels may be transmitted to target markets or countries even when the crisis is considered dead or eased. This holds more seriously for emerging/developing and/or markets that are not highly integrated, and therefore do not share similar cyclical relationship with global markets (or origins of shocks), making them naturally insulated or decoupled from immediate spillovers from crisis. For this reason, we argue that most emerging/developing markets may generally be decoupled from initial spillovers of shocks during crisis and that examining the occurrence of contagion based on the "shift-contagion" theory may usually lead to the conclusion of "no contagion". This stands to diffuse the widely held opinion that '*when the US [developed economies] sneeze, all other economies catch a cold*'. In contrast, the truism is that the speed and intensity of such infectious spread may be higher in countries with higher proximity to the '*flu-infected*' economy (e.g. USA) than those that are distance apart. In view of the above, we propose to extend the "shift-contagion" theory and postulate a **"delayed shift-contagion"** theory — *thus, increases in cross-market spillovers/risk factors during crisis*.

Two key reasons account for the distinction between "shift-contagion" and "delayed shift-contagion". First, focusing on only crisis periods to establish contagion may be misleading on the grounds that contagion may occur because shocks are in excess due to the crisis or by mere coincidence. Thus, if shocks were not in excess, contagion may not occur through any channel. Secondly, in the crisis period, every economic agent is equally exposed to the shock and so it becomes really difficult to trace the channel of transmission. However, in the immediate post-crisis era and even beyond, it would take really critical factors such as market integration, similarities in cyclical relationships and sector compositions of indices, trade relations, cross-border listings, interactive effects of macro-economic factors, etc., or other forms of significant connectivity for contagion to occur. Third, the reliance on increased correlation during crisis to denote contagion may be misleading since correlation will expectedly be high during periods of market volatility — see also Bekaert et al. (2005). It is our considered opinion that policy makers and practitioners would be keen in finding out whether contagion from global shocks, if any, to particularly, emerging financial markets are as a result of excessive shocks or market and economic specific linkages; or whether such shock transmissions occur after the crisis has eased. A more compelling reason to explore avenues for the establishment of the shift-contagion theory in respect of shock transmission after a crisis is the suggestion by extant literature that shocks, particularly from the U.S exert significant influence on other economies during tranquil periods (Dungey and Gajurel, 2015).

To carry-out the test for shift- and/or delayed shift-contagion, we disaggregate the full sample data into sub-samples, taking into account the 2007–2009 global financial crisis. The choice of this crisis period is because it is arguably the major global financial crisis after the Great Depression that occurred between 1929 and 1932. A great deal of uncertainty surrounds when the GFC actually started and ended. However, for the purpose of this paper, we use the crisis period suggested by Dungey and Gajurel (2015). Thus, we choose a crisis start date of August 9, 2007[11]; a period corresponding with the beginning of European Central Bank's (ECB) intervention in the market and the seizure in the banking system by BNP Paribas intimating the halt of activities

[11] Larry Elliot, the Economist editor, in the 7th August, 2011 edition of the Guardian also affirms same start date.

Table 2
Summary statistics.

	Botswana	Egypt	Kenya	Morocco	Nigeria	South Africa	Asia ex-Japan	EUSTXX	FTSE100	S&P 500
Panel A: Stock markets indices										
Mean	−0.001	0.003	0.003	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Std. Dev	0.047	0.043	0.039	0.026	0.044	0.041	0.029	0.035	0.030	0.024
Skewness	−14.709	−0.871	0.157	−0.486	−0.285	−0.041	−0.727	−1.121	−1.390	−0.923
Kurtosis	318.490	6.626	7.919	5.811	6.170	8.555	7.519	10.406	16.528	12.145
J–B	2861388*	461.109*	692.339*	252.057*	295.677*	879.537*	642.056*	1706.458*	5435.601*	2480.793*
Q(20)	26.574	43.806	22.899	31.678	34.757	35.203	33.861	47.307	61.685	39.493
	[0.148]	[0.002]	[0.294]	[0.047]	[0.021]	[0.019]	[0.027]	[0.001]	[0.000]	[0.006]
B–G	1.205	1.943	1.049	1.462	1.507	1.762	1.654	2.527	3.296	2.083
	[0.242]	[0.008]	[0.401]	[0.088]	[0.072]	[0.021]	[0.036]	[0.000]	[0.000]	[0.004]
Panel B: USD exchange rate against the domestic currency										
Mean	0.001	0.001	0.000	−2.12E-05	0.001	0.001				
Std. Dev	0.019	0.007	0.010	0.011	0.010	0.024				
Skewness	1.329	13.465	−0.358	0.313	1.811	0.369				
Kurtosis	13.034	272.492	9.625	4.133	15.883	5.763				
J–B	3070.394*	209050*	1265.505*	47.704*	5103.735*	233.127*				
Q(20)	26.088	57.233	41.152	16.818	47.272	32.378				
	[0.163]	[0.000]	[0.004]	[0.665]	[0.001]	[0.039]				
B–G	1.292	2.356	2.000	0.907	2.440	1.573				
	[0.176]	[0.001]	[0.006]	[0.578]	[0.001]	[0.053]				
Panel C: EUR exchange rate against the domestic currency										
Mean	0.001	0.001	0.000	1.36E-05	0.002	0.001				
Std. Dev	0.016	0.015	0.016	0.003	0.017	0.022				
Skewness	0.983	0.928	−0.513	−0.298	0.458	0.248				
Kurtosis	8.826	14.314	5.560	4.615	6.420	6.084				
J–B	1077.316*	3746.548*	216.811*	84.511*	357.222*	278.179*				
Q(20)	34.526	32.646	18.911	22.326	25.040	39.070				
	[0.023]	[0.037]	[0.528]	[0.323]	[0.200]	[0.007]				
B–G	1.642	1.617	0.931	1.204	1.357	1.727				
	[0.038]	[0.043]	[0.548]	[0.244]	[0.136]	[0.025]				

Notes: Data are weekly running from January 2003 to February 2016. '*' denote statistical significance at 1%, J–B is the Jacque–Bera statistics for estimating normality, Std. Dev is standard deviation, Q(20) is the Ljung–Box statistics and B–G denotes the Breusch–Godfrey LM statistics. Both the Q(20) and B–G are used to test serial correlation in returns at 20 lags. The p-values for these tests are reported in squared brackets.

in three funds with specialty in U.S mortgage debt. With this, the considered crises end point is May, 8, 2009, consistent with end of the recession in the US.

The disaggregated data thus, comprise (a) a pre-crises period from January, 10, 2003 to August, 7, 2007; (b) a crisis period from August, 9, 2007 to May, 5, 2009; and (c) a post-crisis period from May, 8, 2009 to February, 12, 2016. The suggestion by Claessens et al. (2010), Mishkin (2011), and Dungey and Gajurel (2015) are in favour of splitting the crisis into phases: the turmoil phase (from August 2007 to mid-September 2008, until the demise of Lehman Brothers) and the acute phase (after the collapse of Lehman Brothers until May 2009). Phase I (the turmoil phase) captures the sub-prime crisis and its effects in financial markets globally. For example, August 2007 marks the seizure in the banking system by BNP, a credit freeze in interbank markets, central banks provision of substantial liquidity support to banks, and the action of governments to rescue financial institutions such as ABN Amro in the Netherlands, Northern Rock in the UK, and Bear Stearns in the US — see also Dungey and Gajurel (2015). Phase II (the acute stage) marks the bankruptcy of the Lehman Brothers, when turmoil in the financial markets led to the failure of a large number of financial institutions globally, with various governments interventions, especially the G20's cutting of interest rates, provision of various fiscal stimuli and bail-out packages, and pursuing quantitative easing policies in an attempt to avoid the recession becoming a slump.

To incorporate the aggregation of the sub-samples for examining contagion, we apply the K–S statistical test (see Eq. (8)) to examine whether or not the conditional distribution function (CDF) of the mean conditional value-at-risk (CoVaR) of two succeeding sub-samples are significantly different. For instance, we test whether or not the expected value of CoVaR for pre-crisis period is significantly different from that of Phase I; if that of Phase II is significantly different from that of Phase I; and lastly, if that of the post-crisis period is significantly different from that of Phase II.

It must be emphasized that the hypothesis test used in this study differs from that of Forbes and Rigobon (2002). Their test statistic to determine contagion was calculated using estimated sample variances. However, Corsetti et al. (2005) and Daryl and Biekpe (2002) suggest that the Forbes and Rigobon (2002) approach has arbitrary and unrealistic restrictions on the variance of country-specific shocks. Corsetti et al. (2005) believes that a change in variance might be driven by an increase in the variance of a common factor, which then causes a higher than usual volatility in other markets. Testing for contagion, therefore, does

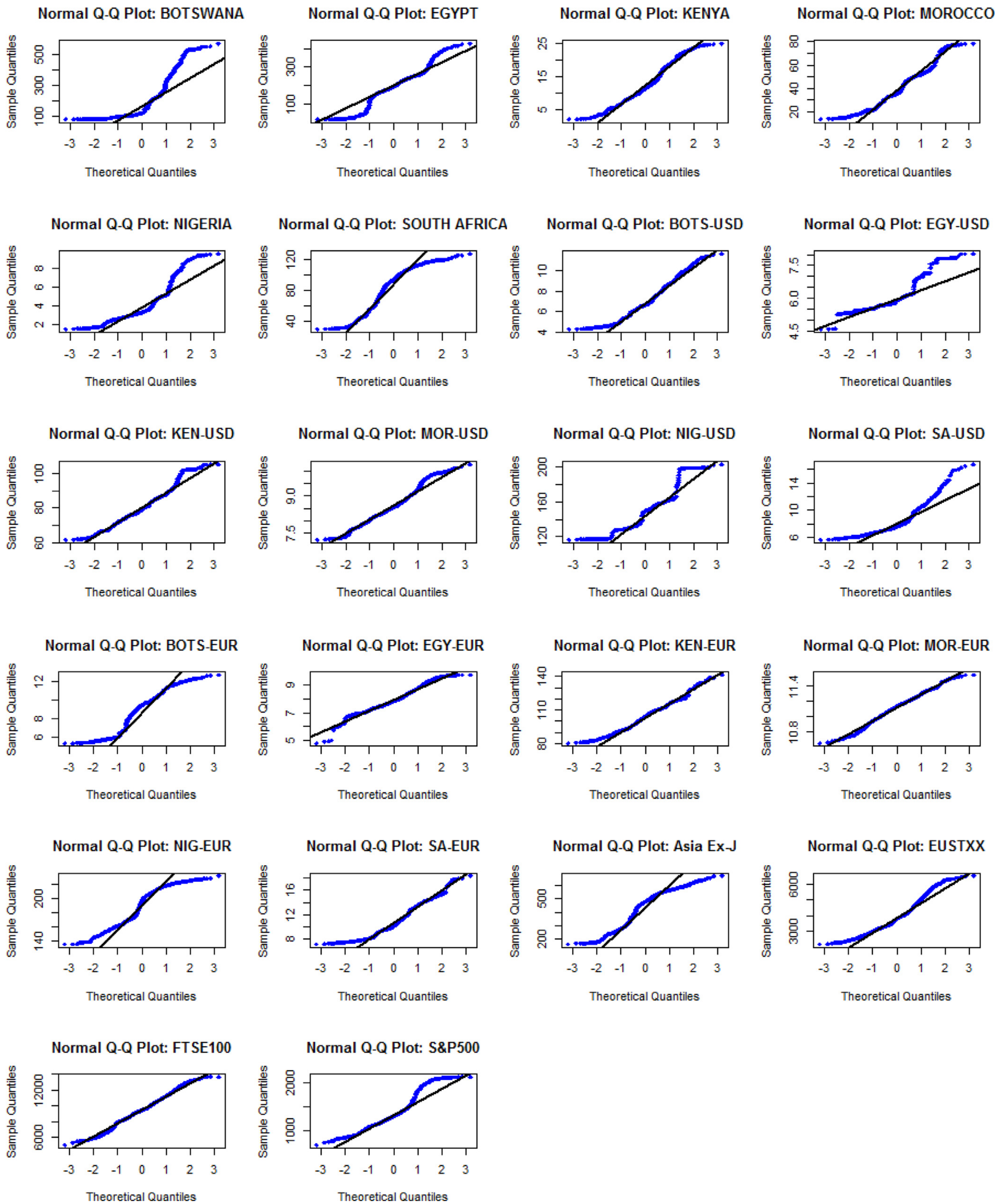

Fig. 1. Normal qq plots of all returns.

not need to be conditional on observing a rise in correlation, as contagion is likely to be defined as co-movements which are too strong relative to what can be expected from an unchanged transmission mechanism (Daryl and Biekpe, 2002). The KS-test has the advantage of overcoming the restrictive test by Forbes and Rigobon (2002) since the former makes no assumption about the distribution of data. The above motivates why we do not use the Forbes and Rigobon (2002) test statistic measure and correlation to estimate contagion.

Following the two-step copula procedures already described in Section 3.2, we apply the best fit copula approach for each time period to examine spillover effects. At each period, the CoVaR value for African stock returns is obtained at the 95% confidence level ($\beta = 0.05$) conditional on the foreign exchange rate and developed stock returns at the 95% confidence level ($\alpha = 0.05$). Table 3 summarizes the results of best-fit (optimal) copulas and the best copula model when forcing the parameter of dependence to remain constant for each market pair (e.g. Kenya-EUR, Nigeria-FTSE100, etc.).

Table 4 shows the summary statistics and hypothesis tests (based on Kolmogorov–Smirnov statistics, Eq. (8)) for the downside CoVaR values for African stock market returns (for pre-crisis/Phase I, Phase I/Phase II, and Phase II/post- crisis periods) by considering contagion effects from foreign exchange rates and developed equity markets. Graphical results of the temporal dynamics for contagion are reported only for situations where spillover is identified — see Fig. 2. The rest are available upon request due to conservation of space. From Fig. 2, we observe abrupt changes in the time path of the graphs mostly around the early stages of Phase II. The changes correspond with the first quarter of 2009 where the G20 cut interest rates, various fiscal stimuli, and pursed quantitative easing policies in an attempt to avoid the recession becoming a slump. From the mean CoVaRs (%) in Table 4, it is observed that in most cases the CoVaR for Phase I is less than that for the pre-crisis period signifying evidence of contagion. However, the K–S statistic suggests that there is no significant difference between the mean CoVaRs for the said periods, and hence contagion could not be said to have occurred. Evidence for contagion is established where mean CoVaR values are identified to be systematically more negative for a successive period (say, Phase II) than for a preceding period (say Phase I) and the corresponding Kolmogorov–Smirnov (K–S) bootstrapping test statistic is significant. Evidences of contagion in Table 4 are highlighted in bold.

We observe shock propagation from some exchange rate and developed equity markets to African stocks only in Phase II and the post-crisis periods. For Phase II, contagion is identified from the EUR to Morocco, USD to South Africa, FTSE100 to Egypt and South Africa, S&P500 to Morocco and South Africa, and EUSTX to Nigeria and South Africa. In the post-crisis period, only shock from the USD exchange rate to Kenya is observed. The result is somehow similar to Daryl and Biekpe (2002) who found evidence of contagion during the 1997 Asian crisis to South Africa, Morocco, Egypt, and Namibia. Again, Giovannetti and Velucchi (2013) observed that shocks from the collapse of Lehman Brothers 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.

The Morgan Stanley Composite Index (MSCI) — Barra and Hartford Investments' report (2008) on market meltdown around the globe (global stock market performance-4th quarter 2008) shows that during the highest periods (Phase II) of the crisis equity wealth declined sharply, with the U.S suffering most. U.S markets declined by 37%, Japan 43%, Latin America 38%, 51% in China; and in Europe 38.5%. Correspondingly, the well-integrated African markets were not invulnerable, as they recorded the following declines: Egypt 55%, Mauritius 49%, Nigeria 59%, South Africa 33%, and Kenya 31%. More closely related to our findings (especially, the evidence of Phase II contagion) 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 Phase I, but rather through the global recession that followed into the second phase. The findings bring to the fore that, although results for Phase I show no signs of African stock markets affected by (extreme) downward fluctuations in foreign currency and global equity markets, same cannot be said for acute periods of the crisis. This also, brings to mind that related studies that focus on only Phase I estimation results may not present a complete picture on the dynamic interactions among markets.

The evidence of contagion during the acute phase of the 2007–2009 crisis is found for markets that are known to be highly integrated in Africa, though the levels of integration are not the same. The increased susceptibility of these markets to contagion effects may also rest on their 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 markets. It would then be expected that these markets would be the most susceptible to contagion. Morocco and Nigeria are a bit difficult to explain. However, the two markets are relatively large (Nigeria being the largest in West Africa) and well-traded among emerging markets, although not at the levels of Egypt and South Africa.[13] 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 indirect channels may account for the contagion. For instance, stock markets in Africa do not have higher exposure to risks emanating from complex derivative instruments. They have relatively less free-float shares and although they are open to foreign investor participation, the levels of openness are relatively low. Further, stock markets in Africa do not have large numbers of listed firms that are also in the international register — and thus, the likelihood of listed corporates in the international register to carry-on global risks to the local markets is limited.

The deduction is that despite the establishment of second round contagion risk, it thus appears the possibility of Africa to suffer such fate during crisis through the equity market is not intense. Intuitively, the spread of contagion from the GFC to Africa is non-homogenous for individual countries. Commodity driven economies such as Nigeria, South Africa, Botswana,

[12] Robust standard errors are available upon request.

[13] Morocco also has the same weight in the IFC index as Egypt.

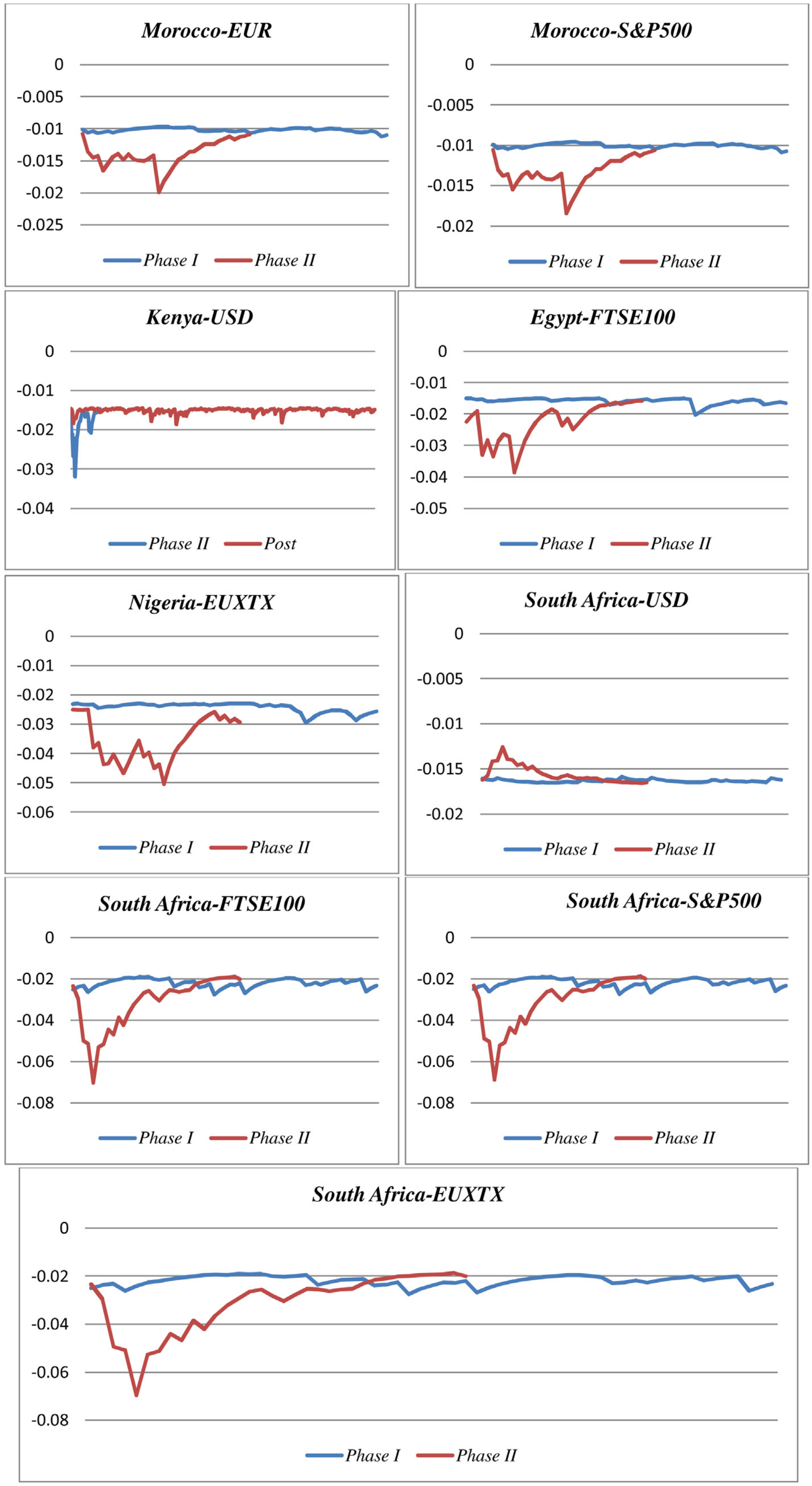

Fig. 2. Downside conditional value-at-risk (CoVaR) for African stock market returns.

Table 3
Best-fit (optimal) copula selection – full sample.

	Copula selected		Copula selected	
	Constant	*Time-varying*	*Constant*	*Time-varying*
	Panel A: USD and African market pairs		*Panel B: EUR and African market pairs*	
Kenya	Gaussian			TV-Student-t
South Africa		TV- rotated Gumbel		TV-Student-t
Egypt		TV-Gaussian		TV-Gaussian
Nigeria		TV-Student-t	Rotated Gumbel	
Morocco	Student-t		Rotated Gumbel	
Botswana		TV-Student-t		TV-Gaussian
	Panel C: Asia ex-J and African market pairs		*Panel D: EUXTX and African market pairs*	
Kenya		TV- rotated Gumbel	Rotated Gumbel	
South Africa	Student-t			TV-Student-t
Egypt		TV-Gaussian	Gaussian	
Nigeria	Student-t			TV-rotated Gumbel
Morocco		TV- rotated Gumbel		TV- rotated Gumbel
Botswana		TV-Gaussian		TV-Gaussian
	Panel E: FTSE100 and African market pairs		*Panel F: S&P500 and African market pairs*	
Kenya	Rotated Gumbel		Rotated Gumbel	
South Africa	Student-t			TV-Student-t
Egypt	Gaussian			TV-Gaussian
Nigeria	Student-t		Gumbel	
Morocco		TV-Gaussian	Rotated Gumbel	
Botswana		TV-Gaussian	Gaussian	

TV denotes time-varying. Optimal Copulas are selected based on the AIC.

and Kenya suffered from drops in export prices and volumes, as well as demand of commodities, among other factors. Simatele (2014) indicates that the negative effects of the GFC on African markets could be attributed to the effects on trade balances possibly arising from export demand shocks and price movements of key commodities. For instance, contagion to the South African Johannesburg Stock Exchange (JSE) was mainly through a deteriorating overall economy with the slump in economic aggregates heightening pressure on the 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 (Simatele, 2014). In the post Lehman Brothers collapse (Phase II of the crisis) between May 2008 and March 2009, South Africa's Johannesburg All-Share-Index (JALSH) index fell by about 46% and the rand depreciated by 23% against the U.S. dollar. The result was dramatic increases in the cost of capital, and a severe contraction in lending, which led to sharp downturns in the retail and manufacturing sectors. In Botswana, lower diamond sales to the 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 Ahmed and Mmolainyane, 2014). Since the Botswana market has higher weightings towards the diamond industry the consequential effects on the local bourse was noticeable.

A second possible channel of shock spillover was the large-share of foreign-owned banks in the continent. The financial distress among parent foreign banks in Western Europe led to some capital withdrawal and calling in of loan advances to African subsidiaries, with equity investments suffering additional contagion risk — especially in markets where banks advanced loans to clients to purchase shares (e.g. Nigeria) (Beck et al., 2009). However, this channel could not cause much havoc as European banks have low equity levels in Africa and also the overall dependence on foreign subsidiaries in Africa on parent bank funding is low. The dilemma on the plausibility of contagion to Africa via the banking sector is still an area that requires further attention. At one breadth the idea towards pan-Africa banks have the tendencies to mitigate contagion risk from European banks, however, to the extent that economies from where these banks have their roots – mostly Nigeria and South Africa – are also unsheltered from the crisis the possibility of additional contagion cannot be discounted — see also Beck et al. (2009).

Another channel for contagion risk to African stock markets was the drop in international capital flows. The advent of the crisis saw a reverse of the hitherto African economies benefit from the global liquidity glut as there were sharp declines in foreign direct investments and increases in the flight of portfolio investments. Simatele (2014) observes that despite the increases in private capital flows into Sub-Saharan Africa (SSA) in the early days of the 21st century, the advent of the GFC registered some declines due to increased investor risk-aversion, tighter global credit conditions, and developments in the bond markets. For instance, 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) — especially Kenya and Ghana postponed their bond issues in 2008. However, the International Monetary Fund (IMF) observes that boom-bust cycle in private financial inflows was less marked than in other regions, largely due to the high share of foreign direct investment over other more volatile forms of private capital. Remittances also fell only slightly and

Table 4
Descriptive statistics and tests for shift-contagion in African stock returns using downside CoVaR.

	$CoVaR_{[1]}$	$CoVaR_{[2]}$	H_0 / H_1	$CoVaR_{[2]}$	$CoVaR_{[3]}$	H_0 / H_1	$CoVaR_{[3]}$	$CoVaR_{[4]}$	H_0 / H_1
Panel A: EUR exchange rate returns									
Botswana	−7.906	−9.438	0.020	−9.438	−14.863	0.000	−14.863	−8.431	0.025
	[1.838]	[3.568]	(0.964)	[3.568]	[0.324]	(1.000)	[0.324]	[3.354]	(0.956)
Egypt	−15.818	−15.653	0.099	−15.653	−21.740	0.000	−21.740	−16.013	0.045
	[1.212]	[0.887]	(0.384)	[0.887]	[5.381]	(1.000)	[5.381]	[1.433]	(0.934)
Kenya	−16.950	−17.721	0.013	−17.721	−20.697	0.059	−20.697	−15.694	0.093
	[3.290]	[3.287]	(0.984)	[3.287]	[5.863]	(0.860)	[5.863]	[0.906]	(0.894)
Morocco	−10.614	−10.202	0.086	−10.202	−13.893	0.8 85	−13.893	−10.272	0.000
	[1.052]	[0.304]	(0.892)	[0.304]	[2.078]	(0.000)	[2.078]	[0.492]	(1.000)
Nigeria	−24.509	−23.845	0.030	−23.845	−33.240	0.000	−33.240	−24.136	0.095
	[1.870]	[1.338]	(0.961)	[1.338]	[6.388]	(1.000)	[6.388]	[2.055]	(0.892)
South Africa	−17.258	−17.597	0.009	−17.597	−19.171	0.039	−19.171	−17.358	0.047
	[0.307]	[0.343]	(0.993)	[0.343]	[2.077]	(0.936)	[2.077]	[0.436]	(0.933)
Panel B: USD exchange rate returns									
Botswana	−7.612	−8.883	0.020	−8.883	−124.363	0.000	−124.363	−8.048	0.031
	[1.525]	[2.960]	(0.964)	[2.960]	[268.660]	(1.000)	[268.660]	[2.783]	(0.612)
Egypt	−15.864	−15.696	0.019	−15.696	−21.893	0.000	−21.893	−16.063	0.044
	[1.234]	[0.903]	(0.263)	[0.903]	[5.497]	(1.000)	[5.497]	[1.456]	(0.934)
Kenya	−15.912	−16.428	0.027	−16.428	−8.419	0.056	−8.419	−15.072	**0.693**
	[2.230]	[2.199]	(0.843)	[2.199]	[−3.922]	(0.859)	[−3.922]	[0.606]	(0.000)
Morocco	−9.498	−9.364	0.016	−9.364	−10.572	0.000	−10.572	−9.386	0.085
	[0.345]	[0.009]	(0.397)	[0.009]	[0.680]	(1.000)	[0.680]	[0.161]	(0.896)
Nigeria	−24.696	−24.174	0.000	−24.174	−35.045	0.000	−35.045	−24.528	0.095
	[2.161]	[1.540]	(1.000)	[1.540]	[7.379]	(1.000)	[7.379]	[2.374]	(0.892)
South Africa	−16.468	−16.310	0.053	−15.578	16.310	**0.595**	−15.578	−16.422	0.004
	[0.143]	[0.160]	(0.456)	[0.160]	[0.967]	(0.000)	[0.967]	[0.203]	(0.999)
Panel C: ASIAJ-ex.J stock returns									
Botswana	−8.711	−10.958	0.019	−10.958	−215.059	0.000	−215.059	−9.481	0.000
	[2.695]	[5.232]	(0.964)	[5.232]	[474.841]	(1.000)	[474.841]	[4.918]	(1.000)
Egypt	−16.153	−15.966	0.099	−15.966	−22.852	0.000	−22.852	−16.374	0.056
	[1.371]	[1.003]	(0.384)	[1.003]	[6.088]	(1.000)	[6.088]	[1.617]	(0.647)
Kenya	−17.030	−17.821	0.013	−17.821	−20.873	0.057	−20.873	−15.742	0.049
	[3.374]	[3.371]	(0.984)	[3.371]	[6.0133]	(0.834)	[6.0133]	[0.929]	(0.592)
Morocco	−10.713	−10.097	0.021	−10.097	−13.477	0.000	−13.477	−10.161	0.086
	[1.385]	[0.279]	(0.768)	[0.279]	[1.903]	(1.000)	[1.903]	[0.450]	(0.239)
Nigeria	−25.176	−24.332	0.011	−24.332	−35.873	0.000	−35.873	−25.692	0.023
	[2.294]	[1.635]	(0.854)	[1.635]	[7.834]	(1.000)	[7.834]	[4.606]	(0.719)
South Africa	−19.918	−21.929	0.007	−21.929	−31.268	0.024	−31.268	−20.507	0.018
	[1.824]	[2.034]	(0.978)	[2.034]	[12.322]	(0.679)	[12.322]	[2.585]	(0.945)
Panel D: FTSE100 stock returns									
Botswana	−8.922	−11.357	0.019	−11.357	−223.892	0.000	−223.892	−9.509	0.001
	[2.920]	[5.669]	(0.964)	[5.669]	[486.258]	(1.000)	[486.258]	[4.964]	(0.998)
Egypt	−16.087	−15.865]	0.115	−15.865]	−22.161	**0.467**	−22.161	−16.161	0.021
	[1.332]	[0.966]	(0.278)	[0.966]	[5.649]	(0.000)	[5.649]	[−1.486]	(0.856)
Kenya	−17.028	−17.818	0.013	−17.818	−20.869	0.059	−20.869	−15.743	0.074
	[3.372]	[3.369]	(0.984)	[3.369]	[6.010]	(0.860)	[6.010]	[0.930]	(0.261)
Morocco	−10.692	−10.480	0.131	−10.480	−13.433	0.000	−13.433	−10.192	0.071
	[1.391]	[0.439]	(0.137)	[0.439]	[1.885]	(1.000)	[1.885]	[0.462]	(0.245)
Nigeria	−25.145	−24.308	0.011	−24.308	−35.749	0.000	−35.749	−24.595	0.081
	[2.274]	[1.621]	(0.967)	[1.621]	[7.766]	(1.000)	[7.766]	[2.428]	(0.221)
South Africa	−21.479	−21.989	0.054	−21.989	−31.437	**0.354**	−31.437	−20.506	0.069
	[5.546]	[2.057]	(0.742)	[2.057]	[12.466]	(0.000)	[12.466]	[2.585]	(0.827)
Panel E: S&P500 stock returns									
Botswana	−8.746	−11.071	0.003	−11.071	−223.892	0.001	−223.892	−9.509	0.000
	[2.731]	[5.319]	(0.991)	[5.319]	[486.258]	(0.998)	[486.258]	[4.964]	(1.000)
Egypt	−16.162	−15.975	0.098	−15.975	−22.881	0.000	−22.881	−16.954	0.058
	[1.375]	[1.006]	(0.325)	[1.006]	[6.107]	(1.000)	[6.107]	[3.010]	(0.643)
Kenya	−16.956	−17.729	0.013	−17.729	−20.711	0.068	−20.711	−15.698	0.093
	[3.297]	[3.294]	(0.984)	[3.294]	[5.876]	(0.834)	[5.876]	[0.908]	(0.267)
Morocco	−10.392	−10.036	0.026	−10.036	−13.233	**0.721**	−13.233	−10.096	0.085
	[0.912]	[0.264]	(0.813)	[0.264]	[1.800]	(0.000)	[1.800]	[0.426]	(0.342)

Table 4 (*Continued*)

	$CoVaR_{[1]}$	$CoVaR_{[2]}$	H_0 / H_1	$CoVaR_{[2]}$	$CoVaR_{[3]}$	H_0 / H_1	$CoVaR_{[3]}$	$CoVaR_{[4]}$	H_0 / H_1
Nigeria	−24.896	−24.118	0.031	−24.118	−34.753	0.000	−34.753	−24.465	0.000
	[2.114]	[1.507]	(0.763)	[1.507]	[7.219]	(1.000)	[7.219]	[2.323]	(1.000)
South Africa	−19.869	−21.848	0.008	−21.848	−31.042	**0.439**	−31.042	−20.448	0.047
	[1.796]	[2.002]	(0.984)	[2.002]	[12.131]	(0.000)	[12.131]	[2.545]	(0.613)
Panel F: EUXTX stock returns									
Botswana	−8.785	−11.098	0.031	−11.098	−221.840	0.000	−221.840	−9.578	0.025
	[2.774]	[5.386]	(0.932)	[5.386]	[488.764]	(1.000)	[488.764]	[5.062]	(0.942)
Egypt	−15.945	−15.772	0.088	−15.772	−22.161	0.005	−22.161	−16.161	0.051
	[1.272]	[0.931]	(0.348)	[0.931]	[5.649]	(0.989)	[5.649]	[1.486]	(0.857)
Kenya	−17.032	−17.822	0.024	−17.822	−20.876	0.059	−20.876	−15.743	0.003
	[3.376]	[3.373]	(0.971)	[3.373]	[6.016]	(0.860)	[6.016]	[0.930]	(0.997)
Morocco	−10.513	−10.127	0.086	−10.127	−13.594	0.000	−13.594	−10.192	0.050
	[0.989]	[0.286]	(0.475)	[0.286]	[1.952]	(1.000)	[1.952]	[0.462]	(0.861)
Nigeria	−25.045	−24.232	0.011	−24.232	−35.352	**0.795**	−35.352	−24.595	0.000
	[2.210]	[1.575]	(0.992)	[1.575]	[7.548]	(0.000)	[7.548]	[2.428]	(1.000)
South Africa	−19.918	−21.929	0.008	−21.929	−34.266	**0.198**	−34.266	−20.506	0.006
	[1.824]	[2.034]	(0.990)	[2.034]	[12.321]	(0.000)	[12.321]	[2.585]	(0.988)

Notes: The table reports results for test of 'shift-contagion' in African stocks for downside conditional-value-at-risk (CoVaR) using the Kolmogorov–Smirnoff (KS) statistics. Standard deviations (%) for CoVaR are in squared brackets. P-values for the K–S statistic are in brackets. CoVaR subscripts [1], [2], [3], and [4], respectively represent pre-crises, phase I, phase II, and post-crisis periods.[12]

official financing flows increased in response to efforts by the IMF and other agencies to scale up support in response to the crisis (IMF, 2010).

The IMF African Economic Output report released in 2010 suggests that during the GFC, movements in the terms of trade outweighed the impact of the reversal in private capital flows for many countries. For oil producers, a massive deterioration in their terms of trade, equivalent to 27% of GDP in 2009, was exacerbated by the reduced availability of private external financing. For non-oil producers, however, terms of trade gains in 2008–09 largely offset the financing shock. With multilateral institutions scaling up support, an increase in official financing partially compensated for the reduction in private capital inflows during the crisis and the share of official flows in total financing to the region rose sharply. Although, it thus appears the declines in international capital flows were not seen to be substantial during the acute phase of the crisis, because of the small size of the African financial system, even a small absolute drop in capital inflows could have a relatively large effect on its markets (Beck et al., 2009). Aside the above, shocks could also be propagated through other indirect channels such as changes in the overall international regulatory architecture and the real economy (see also, Beck et al., 2009; Ncube et al., 2014; Simatele, 2014).

From the above and the findings of this paper, it appears the discourse on what may constitute the possible channels of global shock transmission to Africa is unsettled: is it predominantly through commodities and real sectors of the economy or the stock market route? On account that we do not identify intense and widespread episodes of contagion to Africa via the equity markets, we wish to agree with Beck et al. (2009: 12) "that while financial market underdevelopment seems, *prima-facie*, to help countries isolate themselves against immediate contagion; it also reduces the ability of the real economy to cushion the impact of the crisis". Implicitly, we argue that despite the notion that a well-integrated and highly developed market may present fertile grounds for shocks spillover, African economies must continue the integration agenda of its segmented equity markets. However, the degree and extent of both inter- and intra-regional integration ought to be pegged at certain optimal levels in order to reap benefits from scale economies. Such aggressive pursuit of integration will not only help in risk diversification but also help smooth the impact of shocks.[14]

Given that some evidence of contagion is established not in Phase I but Phase II (which is also part of the crisis period) we are unable to conclude with precision whether or not the 'shift-contagion' theory holds for African stock markets. However, we can conclude that African stock markets were completely insulated from adverse shocks of the global financial crisis at the initial stage, and only suffered marginal effects during the acute stream of the crisis. Thus, if the GFC is defined only in terms of phase I, we can conclude that the definition of shift-contagion ought to be extended to include '*delayed-shift contagion*'. This is consistent with the view that global shocks propagation to developing markets may stagger during crisis and intensify post-crisis (see also Dungey and Gajurel, 2015). A practical implication from the results is that given the relatively scarce resources and levels of technological know-how available to African governments, efforts to wean the continent's equity markets from adverse effects of global market crashes should be geared towards plans and programmes to mitigate the shocks not at the early stages but latter stages, where the effects to Africa could be pronouncedly felt.

5. Conclusion

The paper examined currency and developed equity markets contagion to African stock markets. The examination for

[14] See also Beck et al. (2009).

contagion is situated within the Forbes and Rigobon (2002) shift-contagion thesis. Principally, we were interested in finding out whether contagion occurs more in tranquil periods (especially post-crisis) or during crisis durations. Of great contribution of the study to literature is the examination of tail-spillover effects with particular attention to the quantification of and testing for the impact of downside movements in foreign exchange and developed stock markets on the (extreme) downside risks in African stock markets. Using data of weekly periodicity, the empirical analysis captured the pre, during (both turmoil and acute), and post periods of the 2007–2009 global financial crisis. We analyzed contagion by comparing (extreme) downside cumulative mean distribution conditional value-at-risk values for African stock markets for two successive periods and tested the significance of the systemic spillover using the Kolmogorov–Smirnoff (KS) bootstrap technique. We used the KS statistic to test the hypothesis of equality or no systemic impact between the conditional African stock market return quantiles (for different successive sub-samples). CoVaR values are computed from four copula specifications — *normal Gaussian, Student-t, Gumbel and Rotated Gumbel.*

The results indicate contagion from some exchange rate and developed equity markets to African stocks only in Phase II and the post-crisis periods. For Phase II, contagion is identified from the EUR to Morocco, USD to South Africa, FTSE100 to Egypt and South Africa, S&P500 to Morocco and South Africa, and EUSTX to Nigeria and South Africa. In the post-crisis period, only shock from the USD exchange rate to Kenya is observed. The results support the position expressed by Kodongo and Kalu (2011) and Boako and Alagidede (2017) that the EUR and USD exchange rates may not command substantial premium in African stock markets. The evidence of contagion during the acute phase of the 2007–2009 crisis is found for markets that are known to be highly integrated in Africa, though the levels of integration are not the same. The findings are consistent with the view that global shocks propagation to developing markets may stagger during crisis and intensify post-crisis. A practical implication from the results is that given the relatively scarce resources and levels of technological know-how available to African governments, efforts to wean the continent's equity markets from adverse effects of global market crashes should be geared towards plans and programmes to mitigate the shocks not at the early stages but latter stages, where the effects to Africa could be felt. Further we argue that despite the notion that a well-integrated and highly developed market may present fertile grounds for shocks spillover, African economies must continue the integration agenda of its segmented equity markets. However, the degree and extent of both inter- and intra-regional integration ought to be pegged at certain optimal levels in order to reap benefits from scale economies.

We implore further studies not to only examine the channels of shock transmission but also find answers to the following questions: (i) How have well integrated African financial markets fared in the midst of global shocks? (ii) At what stage of integration, interdependence, and development can African markets expect to experience the benefits of integration and interdependence, without the fear of contagion? (iii) Should African financial markets that are not yet integrated be dissuaded from integrating due to risk dimensions of globalization and integration? (iv)Would the adherence to 'iii' not preclude Africa from sharing in the genuine benefits of globalization and modernization?

Among the possible channels for further exploration are: first, considering the relative poverty and underdevelopment nature of the African economy, it would be interesting to find out how information flow between Africa and the developed world could affect flow of funds across borders and necessitate home bias[15] (see Albuquerque et al., 2009). For this reason, the impact of the amount of telephone traffic and ratio of value of imports of newspapers from the global economy — example US, (quantified in the US currency) to domestic GDP (see Bekaert et al., 2014), and geographic distance between a country and the US (see Bekaert et al., 2014) could be examined. Second, because financial and economic integration largely result in susceptibility to shocks, the inclusion of trade and financial openness in the transmission mechanism model may be a laudable idea.[16] Third, to address the shortfall identified in Pritsker (2000) about how dealer large financial institutions in the financial markets can act as conduits for shock spillover,[17] we propose for further studies to consider two proxies of banks in Africa to explore the role of the banking sector in transmitting global shocks to Africa. First, equity prices of banks in domestic African country listed in either a local stock exchange or an international register; and second the Bank for International Settlements data measuring the degree of claims of domestic banks to banks in U.S or the rest of the world by way of loans, deposits, or other assets could be used. Bekaert et al. (2014) note that such exposure affects the domestic banking sector directly and indirectly affects other stocks.

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[15] Home bias refers to the likelihood for investors to invest in domestic markets rather than foreign markets even when there are greater diversification opportunities.

[16] Kaminsky and Reinhart (2000) and Forbes (2004) align trade openness with contagion and spillovers.

[17] Pritsker (2000) asserts that heavily concentrated markets usually encounter liquidity challenges emanating from shocks spillover from dealer firms.

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