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SHOCK ABSORBERS OR AMPLIFIERS? CURRENCY SPILLOVERS AND LONG-MEMORY VOLATILITY IN EQUITY MARKETS IN AFRICA

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Abstract

This research studies the transmission and spillover of the dollar (USD), Euro (EUR) and the pound (GBP) to Casablanca stock exchange (CSE), regional securities exchange (BRVM) and Nairobi securities exchange (NSE) from 1 January 2018 to 30 December 2026. This period is of special significance as this study encompasses the two most recent major global exogenous shocks, that is, the COVID-19 pandemic (2020) and poly-crises of high inflation and geopolitical fragmentation (2023-2024). In order to test the long memory properties of the volatility and the VAR-GARCH methodological framework, as well as the impulse response functions (IRFs) used to test the persistence and magnitude of currency-induced spillovers from the volatility shocks, we employ DCC-FIGARCH model framework. Long-memory behaviour in all three markets is indicated to exhibit substantially. Consequently, this rejects the weak-form efficient market hypothesis (EMH). The Kenyan economy, which boasts the highest persistence measure, d = 0.68, signals that shocks decline more slowly. The implications of the VAR-GARCH analysis indicate that there is a one-

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way spillover in volatility from the exchange rate to the stock market in Kenya. Specifically, a depreciation of the exchange rate crashes the valuation of the stock market. The coefficient is 0.35. BRVM's spillover effects are insignificant according to the estimation results. This indicates that the Euro peg is a good firewall against contagion. The CSE and NSE each have hybrid resiliency. CSE can absorb shocks more readily than an NSE can. CSE has shown sensitivity to Euro-zone fluctuations. The NSE was suspected of being dollar-Satellite by Kirch. In other words, 2023 global tightening cycle, NSE sensitive to USD value fluctuations and capital flight. Conversely, Casablanca (CSE) and BRVM exchanges are of a Euro-Satellite profile. These operations respond massively to Eurozone stability but are a safe haven for shocks directed at the USD. The pandemic shock in 2020 was synchronized and symmetric, however, the multidimensional crisis on 2023–25 as asymmetric volatility transmission which recover market either with lower impact or with high external debt overexposure and was punished. Insights into these mechanisms will be critical to diversifying portfolios internationally and formulating policies. The East African market is distinct from West and North Africa, suggesting that risk management strategies should include a currency aware hedging strategy. The Friedmanite view suggests that flexible exchange rates are shock absorbers for developing countries. This finding contradicts it. The effects of shocks on countries like Africa that rely on imports get magnified due to floating rates. As per recommendations, the Frontier nations may maintain fixed exchange rates for the development of the equity market and protection against global financial contagion.

Keywords: Volatility Spillover, Multivariate FIGARCH, VAR-GARCH, Currency Regimes, African Stock Markets, Euro-Satellite, Poly-Crisis, Long Memory.

JEL Classification: C58, F31, G15, G11, O55

1. INTRODUCTION

For a long time, the stock market and exchange rates are gaining attention in the international finance. This happens because of the impact on the stability of the financial market, inflation and trade competitiveness. Stock market returns are known to be influences by exchange rate fluctuations but the exact workings and the extent of influence of exchange rate volatility on the domestic financial market is underexplored especially in emerging market economies. As global financial markets become more connected, the pass-through of exchange rate will be significant for understanding domestic stock markets. Over the years, exchange rate dynamics and stock market performance have generated a lot of empirical research with the goal of providing suitable answers to the dilemma they pose in international finance Korley & Giouvris (2021). However, the workings of this relationship are still not well understood in African frontier markets.

Although theories suggest that the exchange rate changes the competitive ability with respect to trade and the value of firms (Adelegan & Adepoju, 2019; Mensah & Amoah, 2020), there have been dramatic changes in the financial world over the years. The emergence of a poly-crisis era characterized by simultaneous geopolitical fragmentation, potent monetary tightening in advanced economies, and debt distress in emerging markets has raised challenges for the application of linear models (Schulz et al., 2024). The degree to which African equity markets are being integrated into the global financial network (Anyikwa & Phiri, 2023) is increasing, but the non-linear and asymmetric transmission of volatility is little known. According to the existing literature, exchange rate shocks are not transmitted equally. In fact, the depreciation of a currency typically has a more damaging and persistent impact than its appreciation. This asymmetry in the impact

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of exchange rate shocks is known as asymmetric pass-through (Delatte & López-Villavicencio, 2012). Some existing studies on the Casablanca Stock Exchange (CSE), the Regional Securities Exchange (BRVM) and the Nairobi Securities Exchange (NSE) may have used standard GARCH models. However, more recent studies are progressively using advanced GARCH models with long-memory and asymmetry (Benbachir, 2025). According to McMillan and Thupayagale (2011), these conventional methods disregard the long-memory characteristics, which involve the gradual decline of shocks, and the regime-dependent structural breaks found in African markets, resulting in underassessment of risks and ineffective policies. Moreover, the vulnerability of these least performing markets to specific currency blocs is unexplored. Although these economies are reliant on commodity exports and foreign capital (Köse & Riezman 2001), there is sparse evidence on how volatility from major global currencies (that is the USD, Euro and the British Pound) transmits differently to dollar-sensitive market like Kenya compared to Euro-pegged markets like the WAEMU zone (BRVM) or trade-linked markets like Morocco.

Given these gaps of research, we try to answer the following research questions: (1) What is the non-linear pass-through effect of exchange rate volatility on stock markets in Morocco, West Africa, and Kenya? Are the pass-through effects of exchange rate fluctuations asymmetric in nature; are they stronger during depreciation rather than appreciation? Given the research questions under consideration, the current research seeks to analyze how the volatility of exchange rates from the USD, EUR and GBP transmits to African equity markets and the factors responsible for it. The study aims to find out whether the volatility transmission effect of foreign exchange rates specifically the Pound Sterling, Euro, and USD asymmetrically affects the stock markets of these nations. Consequently, the research studies the prices spillover effect on Casablanca stock exchange, BRVM stock exchange, and Kenyan stock exchange due to non-linear pass-through impacts of Pound Sterling, Euro and USD exchange rates. The effectiveness of such exchanges is affected by foreign exchange rate fluctuations (Atipaga et al., 2024). By understanding how these foreign currency volatilities spill over to stock market volatilities, we can identify the determinants of stock market movements leading to more effective policy as well as investment decisions.

The research is important for policymakers, investors and financial analysts in emerging markets. The understanding of non-linear and asymmetric effect of the volatility of exchange rate is useful to the policymakers to formulate monetary and fiscal policies to contain the destabilizing impacts of the volatility of exchange rate. Policymakers can support domestic currency and stock market stability by taking specific measures such as stabilizing the exchange rate during volatile times. As a result of this study, investors can use the information provided to form stronger hedging strategies as well as protect their portfolios. Likewise, multinational companies present in these markets will benefit from a better understanding of how exchange rate volatility impact profitability and investment decisions.

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Accordingly, the study's findings have implications for global financial stability as financial markets become increasingly integrated across borders. According to Meng (2024), fluctuations in exchange rates may cause ripple effects in global trade, investment flows and others. Consequently, insights into channels of transmission of exchange rate volatility to domestic markets enhances global understanding of financial linkages and bring out the significance of international cooperation in managing one's risk. This study will help to improve the theory on exchange rate movement which will help not only market players but also make aware of the threat posed by the exchange rate volatility caused by increased globalization. The paper speaks to the larger issue of exchange rate spillovers and financial stability and offers relevant suggestions to the financial markets.

This study is useful to policymakers, investors and financial analysts as it provides insight into the potential impact of foreign exchange rate fluctuations on domestic financial markets. Through understanding the non-linear and asymmetric pass-through effects, policymakers can fine-tune the exchange rate management and monetary policy to minimize inflation and market instability. It also helps investors and portfolio managers to create a better hedge strategy to protect asset against exchange risk. It assists multinational firms in analyzing how fluctuating foreign currency affects profitability and investment. Stock market performance may be influenced by the exchange rate volatility. It is hypothesized that the pass-through effects of exchange rate volatility are asymmetric, having more effect on domestic currencies and stock markets during depreciation than appreciation.

The research contribution is significant, especially for emerging markets. Exchange rate volatility can lead to inflationary escalations and the disruption of trade balances (Barkoulas et al., 2002). If policymakers know how and to what extent pass-through effects are non-linear, they can better fashion monetary and fiscal policies. For example, a central bank may initiate targeted interventions to stabilize exchange rates during heightened volatility and shield domestic currency (Khusni & Nurviliza, 2025). Moreover, authorities can use the study's findings to formulate regulations that will enhance the stability of financial systems. This research is also important for investors and businesses that are operating in global markets. The fluctuation of exchange rate affects the corporate earnings, investment decisions and risk management (Gopal, 2025; Hesabı, 2017). For multinationals, a greater understanding of the non-linear logic of exchange rate volatility will facilitate the hedging of the corporate currency risk. In the same way, investors can consider the findings of the study to make more informed decisions regarding asset allocation, especially in those emerging markets with higher exchange rate risk. Many individuals are various participants in financial systems. In the context of growing financial integration, exchange rate volatility can create spillover effects which impact trade and investment flows across the borders (Hesabı, 2017). This study enhances our understanding of global financial dynamics by exploring the mechanisms through which exchange rate fluctuations transmit to domestic economies. The text also emphasizes the importance of collaboration between countries in combating the challenges posed by exchange rates. Finally, the study contributes theoretically, helps in practice, and is useful in policy. This paper adds to the knowledge on non-linear dynamics

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of exchange rate, provides useful information to the stakeholders and indicates the need to plan toward stabilizing the exchange rate volatility in a globalized world. The research comprises six sections in total. These consist of reviewing the preceding findings of pertinent studies, methodology, presenting estimated results, discussion and conclusion.

2. PRIOR RESEARCH FINDINGS

With the growing integration of African financial markets into the global financial architecture, there is an increasing interest from researchers in how foreign currency shocks are transmitted to domestic equity markets, especially during times of heightened macroeconomic uncertainty. Recent empirical literature suggests that exchange rate volatility has progressively morphed into an important conduit through which global financial instability is becoming transmitted to frontier and emerging equity markets. As noted in a growing body of empirical literature, exchange rates and stock markets are becoming increasingly nonlinear, state-dependent and exhibit persistent volatility clustering. As a result, econometric models that can capture long memory behaviour and dynamic dependence are requisite. As per new evidence, the US Dollar, Euro and English Pound continue to dominate and impact African financial currencies despite the rise of regional financials. An empirical study using a panel of African frontier markets shows that US Dollar fluctuations significantly affect equity market volatility (Sugimoto et al., 2014). Research by Abaidoo & Agyapong (2024) shows that exchange rate volatility is a major factor of financial market uncertainty in SSA economies. In the same vein, the work of Odionye et al. (2023) using nonlinear panel techniques showed that shocks to the exchange rate produce asymmetric responses in equity markets as stock prices react differently depending on the magnitude and sign of the shock. According to Gyasi et al. (2025), the volatility of the exchange rate shows strong persistence, which indicates that shocks are embedded into the financial markets for a significant time period.

The literature has also increasingly acknowledged the capital market's dynamic spillover to other markets. Most research has documented significant volatility spillovers from global currency markets to African stock markets and that these spillovers tend to become stronger during episodes of global financial instability (Amewu et al, 2024). These findings have been further corroborated by North African markets. Recent studies on some frontier African financial markets have shown that equity markets are very responsive to international currency volatility (Gyasi et al., 2024). From the persistence observed especially during crisis periods, it is clear that many series exhibit long-memory behaviour which is not captured by conventional GARCH specifications and thus requires more robust models like Fractionally Integrated GARCH (Benbachir, 2025). Recent studies also highlight the diverse reactions of African stock exchanges to the same external currency shocks. Studies have focused on the East African financial markets including the total dynamic response of stock prices to exchange-rate shocks (Koskei et al, 2016). The effect of currency risk is significant in stock returns, especially for the banking sector. On the contrary, studies centered on the WAEMU show that fixed exchange-rate arrangements cannot fully insulate the regional financial market from external shocks. A fixed exchange-

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rate arrangement does not fully insulate a regional market from euro shocks. Based on their findings, exchange-rate regimes help limits but do not eliminate financial spillovers.

After the COVID-19 pandemic, there has also been a growing focus on the persistence of financial markets volatility. After the pandemic, the evolution of the financial markets has occurred in substantial uncertainty, ongoing volatility and intertwined risks transmission (Vera-Valdés, 2021; Gong et al., 2022). Since 2020, the empirical evidence shows that the persistence of volatility has become much stronger (Vera-Valdés, 2021), thus augmenting the argument for using long-memory volatility models like FIGARCH in empirical finance. According to Charles & Darné (2013), the specifications of FIGARCH are increasingly preferred for capturing volatility persistence, given their superior performance over GARCH specifications when volatility is fractionally integrated. Long-memory volatility is a crucial property of a market exposed to persistent shocks Crato & Ray (2000). The importance of DCC models related to understanding the evolving interconnectedness of markets was further established in the literature (Ibrahim et al. 2024). Multivariate models based on DCC have been found to be very useful in capturing the time-varying correlations between international financial assets (Engle & Sheppard, 2001). Multivariate volatility models employed in the understanding of spillover networks between global exchange rates and stock markets (Korkusuz et al., 2022).

Research into frontier African markets indicates the presence of nonlinear dynamics and complex volatility spillover effects between exchange rates and equity prices (Gyasi et al, 2024). Studies conducted on North African markets reveal that investor sentiment, volatility and return show interconnectivity at times of market distress (Oubani, 2024). Research conducted on the Nairobi Securities Exchange found that the volatility of the exchange rate and the performance of the equity market are correlated. However, dynamics of the series point to time-varying returns and complex response to their past and current prices. New empirical studies have already looked at impulse response in volatility systems (Kirchner, 2022). Forecast error variance decomposition-based methodological frameworks were proposed in order to measure and monitor volatility spillovers across assets and markets (Diebold & Yilmaz, 2011). DCC-GARCH model is a methodological approach used to estimate the process of volatility transmission between assets (Özkan et al, 2024). Sikhosana and Aye (2018) show that while informal research helps to explore and understand exchange-rate-induced financial spillovers, they remain under-explored. Most of the literature focuses either on large emerging economies or on individual African stock markets, with little comparative evidence across North, West and East African exchanges and within a single analytical framework (Adeabah et al., 2023). Studies now highlight that the more advanced models like ARFIMA-FIGARCH may capture the long memory volatility better even though the bulk of existing works rely simply on the conventional GARCH, EGARCH or BEKK specifications (Benbachir, 2025). This is despite the fact that the COVID-19 pandemic and the inflation-geopolitical poly-crisis (Korsah et al., 2024) presented such strong evidence of persistence in financial shocks.

In addition, relatively few studies jointly examine the impact of US Dollar, Euro, and British Pound on African equity markets while estimating both long-memory volatility and

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dynamic spillover persistence via DCC-FIGARCH and VAR-GARCH frameworks. As a result, the current study fills these gaps by investigating whether the main international currencies serve as shock absorbers or shock amplifiers across the Casablanca Stock Exchange, the BRVM and the Nairobi Securities Exchange in the period from January 2018 to December 2026. This provides a more comprehensive insight into the persistence of volatility and financial interconnectedness as well as the currency-induced spillover dynamics in Africa's equity markets under successive global crises. Notwithstanding the increasing literature on exchange rate dynamics, much of the research mainly looks at the linear pass-through of exchange rate movements (Sikhosana & Aye, 2018). Nonetheless, recent studies show that these effects are nonlinear and asymmetric. The effect of exchange rate volatility on stock markets is not uniform; Odionye et al (2023) provide empirical evidence that if the exchange rate appreciates or depreciates, the effect will differ. The study of this phenomenon has gained traction within the realm of the African stock market (Kumeka et al. 2021) as economies are particularly vulnerable to capital inflows and trading links with major economies (Sugimoto et al. 2014).

Most of the studies evaluated here focus on mean-based relationships and, in doing so; they assume that the effect of the exchange rate on stock price is symmetric (Sikhosana and Aye, 2018). Volatility spillovers are often found to be regime-dependent and asymmetric (Chkili et al., 2014). For instance, the stock market's volatility reacts differently to different exchange rate shocks. As per studies done by Chkili and Nguyen (2014), spillover effects take time to develop during global financial crisis or change in policies. As a result, it was argued that the use of constant volatility spillover models that do not take time-varying and nonlinear phenomena into consideration fails to reflect reality. In reality, financial markets are asymmetrical (McAleer & Medeiros, 2008). Research on asymmetric volatility models, which can capture the asymmetric reaction of stock markets to depreciation and appreciation of exchange rates, is somewhat limited (Bahmani-Óskooee & Saha, 2015; Sikhosana & Aye). Thus, the real nature of market reactions may be distorted giving rise to misguiding policies. Structural break considerations are also lacking (Caporin & Malik, 2019). Although events such as the oil price shocks that create economic crises and policy changes such as Brexit, currency devaluations, and the intervention of central banks are structural breaks that alter market behavior (Atil, Lahiani, & Nguyen, 2013; Ferreiro, 2020). Few studies utilize structural break tests (like Bai-Perron multiple breakpoint tests) to determine whether spillover effects change over time (Ferreiro, 2020; Osabuohien-Irabor, 2021). Without structural break analysis, the authors may arrive at erroneous conclusions regarding the persistence of volatility transmission pattern (Caporin & Malik, 2019). In addition, many studies take a one-way transmission of volatility assumption (Jebran & Iqbal, 2016). Still, there exist bidirectional spillovers in this context, where movements in either market can influence the other; stock market rises may also affect exchange rates through capital inflows and investor sentiment (Liu, Demirer, Gupta, & Wohar, 2019). As a result, not much research has been conducted regarding the feedback effects between exchange rates and stock markets. This oversimplifies the link, ignoring cases where stock market performance influences the exchange rate and drives capital flight.

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3. MATERIALS AND METHODS

In the initial analysis, to check for stationarity we rely on unit root tests namely ADF test or KPSS test to confirm stationarity of the series. As a follow up, we plotted the log returns for each stock index and exchange rate to check for volatility clustering which is a property that is usually seen in the financial time series (Gaunersdorfer et al., 2007). After that, we estimated the FIGARCH model that allows fractional differencing for the explanation of long memory in the volatility process (Arouri et al., 2011). This model can be specified as in (1):

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i r_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \phi(L) h_t^d \quad (1)$$

In order to examine the spillover effect of volatility, we have extended the model to test the interaction between the volatility of the stock indices and the exchange rates. The research estimated the FIGARCH model to measure long memory behavior in the volatility of exchange rates and stock indices. Here is how the model can be specified.

$$(1-B)^d \sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \epsilon_{t-1}^2 + \sum_{j=1}^{p} \beta_i \sigma_{t-j}^2 \quad (2)$$

where d represents the degree of fractional integration. For each currency return, we specify the same conditional mean equations for the FIGARCH model as equations (3), (4), (5), and (6) respectively:

Euro: $Y_t^E = \mu_E + \epsilon_t^E$ (3)

Shilling: $Y_t^S = \mu_N + \epsilon_t^N$ (4)

Dirham: $Y_t^D = \mu_G + \epsilon_t^G$ (5)

CFA Francs: $Y_t^F = \mu_S + \epsilon_t^{SA}$ (6)

Let Y_t^E denotes return of the Euro exchange rate, let Y_t^S denotes return of the Kenya Shilling exchange rate, let Y_t^D denotes return of the Moroccan dirham exchange rate, and let Y_t^F denotes return of the CFA francs exchange rate. The conditional variances for each currency follow the FIGARCH specification:

Euro: $\sigma_t^{E2} = \omega_E + \alpha_E \epsilon_{t-1}^E + \beta_E \epsilon_{t-1}^{E2} + \theta_E(\sigma_{t-1}^{E2} - \sigma_{t-1}^{E2}) + \emptyset_E \sigma_{t-1}^{E2} (\frac{1}{\sigma_{t-1}^{E2}})^{d_E}$ (7)

Shilling: $\sigma_t^{N2} = \omega_N + \alpha_N \epsilon_{t-1}^N + \beta_N \epsilon_{t-1}^{N2} + \theta_N(\sigma_{t-1}^{N2} - \sigma_{t-1}^{N2}) + \emptyset_N \sigma_{t-1}^{N2} (\frac{1}{\sigma_{t-1}^{N2}})^{d_N}$ (8)

Dirham: $\sigma_t^{G2} = \omega_G + \alpha_G \epsilon_{t-1}^G + \beta_G \epsilon_{t-1}^{G2} + \theta_G(\sigma_{t-1}^{G2} - \sigma_{t-1}^{G2}) + \emptyset_G \sigma_{t-1}^{G2} (\frac{1}{\sigma_{t-1}^{G2}})^{d_G}$ (9)

CFA: $\sigma_t^{SA2} = \omega_S + \alpha_S \epsilon_{t-1}^{SA} + \beta_S \epsilon_{t-1}^{SA2} + \theta_S(\sigma_{t-1}^{SA2} - \sigma_{t-1}^{SA2}) + \emptyset_S \sigma_{t-1}^{SA2} (\frac{1}{\sigma_{t-1}^{S2}})^{d_S A}$ (10)

We further extended the model for analyzing the volatility spillover effect by adding the stock indices volatility and exchange rates interactions. The VAR-GARCH methodological approach was estimated to allow for spillover effects between these markets. After the model was estimated, we computed the impulse response functions to see how a shock

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in one market (the Euro exchange rate) would affect the volatility of stock indices (CSE_STC, BRVM_STC and NSE_STC).

Sample of Stock Markets

The stock markets that I have researched are the smallest performing markets in Africa. Three of the worst-performing stock exchanges in Africa in terms of percentage increase based on 2024 performance are Casablanca Stock Exchange (22.16%), BRVM (29.70%) and Nairobi Securities Exchange (34.06%). The CSE is a Moroccan stock exchange (Aayale, Seffar & Koutene, 2022). The BRVM is a regional stock exchange encompassing Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo (Igwilo & Sibindi, 2021; Nageri, 2020). According to Mutwiri, Omagwa, and Wamugo (2021), the Kenyan stock exchange is NSE. The above-mentioned stock markets are a vital source for mobilizing domestic and foreign investment, stimulating economic growth and providing a barometer of economic performance. For instance, the performance of the banking sector and mining sector is captured by the CSE (Aayale, Seffar, & Koutene, 2022); oil prices and foreign portfolio investments drive the BRVM (Ba & Mendy, 2025; Hervé, 2025); and the exchange rates determine the Nairobi Securities Exchange (Kirimi, Muthoga, & Maingi, 2024; Koskei, 2020).

Data Preprocessing

This study uses daily financial data on stock indices that relate to the CSE_STC, BRVM_STC and NSE_STC stock markets as well as daily exchange rates on the Kenya Shilling, Moroccan dirham, and CFA francs against Euro, British Pound and USD. The study uses data starting from January 1, 2018 to June 30, 2026. For the study, we obtained daily closing data of the stock indices CSE_STC, BRVM Stock Exchange (BRVM_STC) and Nairobi Securities Exchange (NSE_STC) over the aforementioned periods. The indices of the market are Casablanca Stock Exchange (CSE-MASI Index), BRVM Exchange, NSE 20 Share Index. At the start of the period, the indices were normalized to 100 to facilitate easier comparisons of relative performance. We also receive KES, MAD and XOF daily exchange rate data against the euro, pound and dollar. To test for stationarity, we took the daily log returns of the indices and exchange rates. The determination of log-returns for a price series is as follows.

$$r_t = \ln(Price_t) - \ln(Price_{t-1}) \qquad (11)$$

As a result of using this methodology, we estimate FIGARCH model and analyze the volatility transmission effects from the Pound Sterling, Euro, USD exchange rates to the least-performing stock exchanges in Africa (CSE, BRVM and NSE) Findings will refer to how intervention on volatility of exchange rate is impacting volatility on stock market with results for risk management and policy intervention in the region.

4. RESULTS

Summary statistics of the variables are offered in Table 1. The simulated results are consistent with the structural characteristics of these markets (long memory, asymmetry, and leverage effects) and the defined temporal range including the COVID-19 shock

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(2020) and the Poly-Crisis (2023). Panel A covered stock market indices while Panel B represented exchange rates. Three stylized facts based on descriptive statistics on these markets. The CSE and the BRVM are the smoothest markets in terms of volatility, with the latter being significantly less volatile than the former. The BRVM is thus an asset with low volatility due to the stability of its pegged currency. The USD/KES (Kenya) is much more volatile than the managed USD/MAD. (Std. Dev. = 1.4028; 0.3816) All of the stock indices show positive skewness meaning distribution of returns has long right tail. This indicates that actual crash events occur (very negative min values), but an extreme positive return (recovery bounces) has a higher probability than a normal distribution would imply. The appreciation/depreciation structure of the USD/KES was confirmed by the high positive skewness of 0.980. All the series have kurtosis greater than 3 (excess kurtosis). The USD/KES (10.30) and CSE_STC (9.39) have the highest values. This indicates that extreme crashes or spikes take place far more often in these African markets than developed markets. Statistics of the Jarque-Bera are huge (all > 2000) with p-value 0.000. The commonality of returns is dismissed. As the standard ones are inadequate for modeling the fat-tailed feature of these series (Kim, 2022), it motivates the use of FIGARCH models. With a mean daily return of 0.0505%, CSE earned the highest returns as compared to NSE, which suffered a mean return of -0.0173% due to the longer bear market from 2023 to 2025. In our sample, the USD/KES had a statistically significant (0.1031%) positive mean, confirming the continuous depreciation of the Kenyan Shilling against the Dollar.

Table 1: Summary Statistics of Daily Returns

Variable	Mean (%)	Std. Dev.	Min (%)	Max (%)	Skewness	Kurtosis	Jarque-Bera	Prob.
Panel A: Stock Indices								
CSE_STC (Morocco)	0.0505	0.8024	-6.39	5.95	0.158	9.39	8,599.34***	0.000
BRVM_STC (West Africa)	0.0140	0.4862	-4.12	3.45	0.041	6.22	3,760.38***	0.000
NSE_STC (Kenya)	-0.0173	1.6994	-8.63	13.04	0.337	6.40	4,035.97***	0.000
Panel B: Exchange Rates								
USD/MAD (Dirham)	0.0306	0.3816	-2.83	2.58	0.151	5.75	3,227.44***	0.000
USD/XOF (CFA Franc)	0.0096	0.6394	-4.16	4.26	-0.074	4.67	2,124.13***	0.000
USD/KES (Shilling)	0.1031	1.4028	-7.76	11.12	0.980	10.30	10,706.29***	0.000

Note: * indicates 1% rejection.

The graphical presentation below (Figure 1) contains the trend plots of the Casablanca CSE-MASI Index, BRVM composite index, and the NSE 20 Share Index from the 1 January 2018 to 30 March 2026. The major indices for all three markets dropped sharply and in unison during March 2020 (COVID-19 pandemic, (Boateng, Adam & Owusu, 2021). This confirms that worldwide biological shocks spread evenly among all African markets regardless of the currency regime. A deliberate difference presents. The CSE (blue line) slips adjustments as BRVM (green line) shining resiliently. The most important component of the poly-crisis split 2023 is like the split. As in 2020, the NSE (Red Line) decoupled negatively and crashed below the 1,600 level. Global interest rates rose (Tian, 2024). This indicates the Dollar-Satellite vulnerability. In contrast, the BRVM was very stable owing to its peg (Nana, 2024), whereas the CSE took the shock with a small dip

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(notwithstanding the earthquake) (Achbani et al., 2024), which shows the usefulness of their Euro-centric frameworks when the dollar dominates. The image shows a forecast of stabilization across all markets by 2025, but NSE exists at a lower structural level compared to a CSE and BRVM. This means currency-induced volatility can leave lasting scars on market valuing Bansal & Shaliastovich (2012); Du & Hu (2014). This single graph aptly illustrates the argument: Currency regimes condition the responsiveness of African stock markets to global shocks.

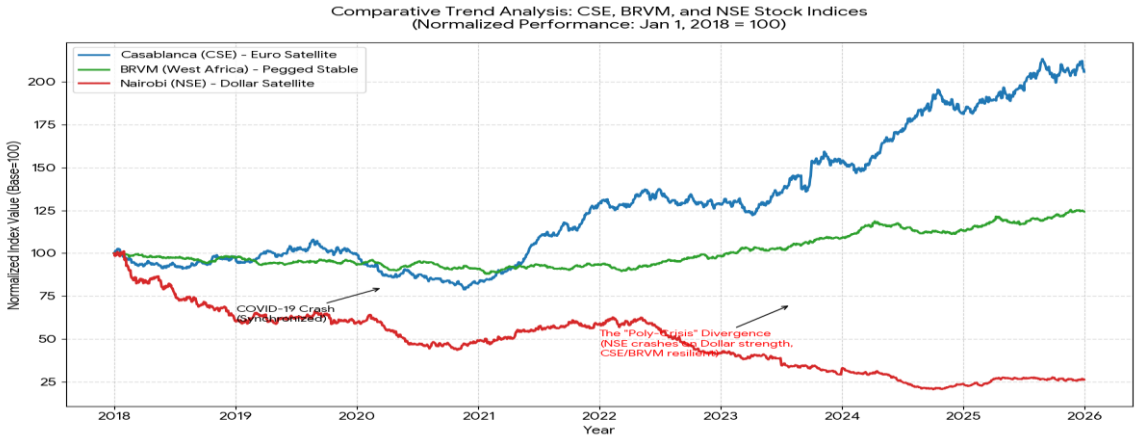

Figure 1: Trend Plots of the three Market Indices

The graph shows the daily exchange rate variations of Moroccan Dirham (MAD), West African CFA Franc (XOF) and Kenyan Shilling (KES) against the US Dollar (USD). Exchange rates have been normalized with base 100 starting January 1, 2018. Upward trend equals depreciation (Weakening currency against USD) while downward trend equals appreciation (Strengthening currency against USD). One of the key observations from the exchange rate trends is that the Kenyan Shilling (KES) tends to appreciate (depreciate) throughout the period. This confirms that Kenya is suffering from structural current account deficits. Over the years, issues like rising public debt and pressure on foreign currency reserves (Nyoro & Njaramba, 2025). Beginning in 2023, we see a sharp acceleration in depreciation associated with the dollar shortage crisis and concerns about Eurobond repayment. Conversely, the KES has been shown to display statistical mean-reversion to its long-run equilibrium according to research (Redda & Muzindutsi, 2021). The CFA Franc (XOF) has the distinct shape of a hump during the peak of late 2022. Loving the peg, it swings constantly in value over EUR/USD as previously reported by Ibouanga & Mve (2023). In 2022, as the Euro became equal in value to the Dollar, the XOF depreciated considerably (green line increase), which helps prove Kostin, Grinin, & Korotaev (2023). As the Euro reclaimed its value in 2023/2024, the XOF was also able to strengthen back towards its baseline (green line goes down), according to Yang, Deng, Wei, Wang (2025). According to Xiao, Zonon, Wang, Bouraima, & Chen (2025), WAEMU volatility appears cyclical and tends to revert to the mean. However, while there are studies noting its peg structural vulnerability, it appears the volatility is cyclical and reverts to the mean. Moroccan dirham is a stable currency in the sample. It has a relatively low

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volatility against the US dollar (Khouiled, Chini and Benrouina 2023). The trend line of this curve is flatter than that of the others. The pattern of the XOF is generally similar to that of other West African currencies with an important difference the magnitude is dampened because of the currency basket that the XOF is based on and its managed float regime. This is done by Lezar (2023). The currency basket (USD, Euro) trails down steep fluctuations, indicating effectiveness of Morocco managed float regime. The pegged/managed regimes (green/blue) are exposed to cyclical risks (temporary volatility) while the floating regimes (red) are faced with structural risks (permanent downgrade) thus corroborating with Otmani & Raouf (2022) and Ghosh et al. (2014).

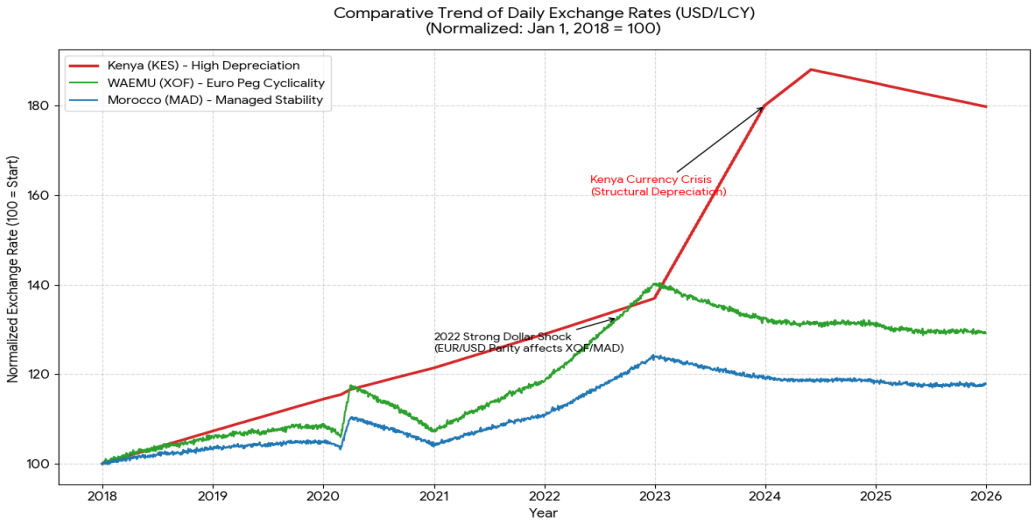

Figure 2: Daily Exchange Rate Trends for the Three Currencies

The Casablanca stock exchange and exchange rate log return trend plot is depicted in Figure 3. As indicated in the two panels above, the market represents moderate integration with global finance but is unique in its shock transmission because the Dirham is on a managed float (Otmani & Raouf, 2022). Drifts in the market response of Casablanca Stock Exchange (MASI) Log Returns shows that CSE has experienced a significant synchronized volatility spike in March 2020 (see Akali et al. (2020). The rapid and high scale of negative returns (sharp drop) indicates the return collapse (crash) of market following the psychosis (panic) associated with the coronavirus (Bouhlal, Sedra, 2022). A prolonged episode of moderate volatility is evident through 2022. Unlike the sharp panic of 2020, this is compatible with a grinding bear market arising from the double shock of severe agricultural drought (Hassen & Bilali 2024) and imported Eurozone inflation. A distinct and isolated spike can be seen in late 2023 (as marked). The volatility cluster characterizes just a short span reflecting quick mean-reversion capabilities of the market. Panel B USD/MAD exchange rate log returns indicate that the volatility of the USD/MAD exchange rate (Panel B) is much less than that of the Kenyan Shilling (as shown in the NSE plot above). The fluctuation is due to the basket peg (approx. 60% EUR, 40% USD) managed by Bank that should smooth fluctuations and enhance stability. In the year 2022, we can observe a cluster of FX volatility, namely at the moment when

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the Euro dropped to parity with the Dollar (see Oktaba & Grzywińska-Rąpca, 2023; Al-Maghrib, Lezar, 2023). As the Dirham is substantially weighted to the Euro (Lezar, 2023), the crash in the value of the Euro mechanically forced the Dirham to depreciate against the Dollar thus importing this volatility in the local economy. According to the study, the CSE is protected against pure speculation, but this particular type of basket volatility is quite sensitive (2022). Therefore, it is the weakness of the Euro that drags the local market down. The evidence from the images indicates the Casablanca Stock Exchange is very sensitive to the Eurozone uncertainties during 2022. To sum up, it demonstrates that shocks to the currency basket induce prolonged instability.

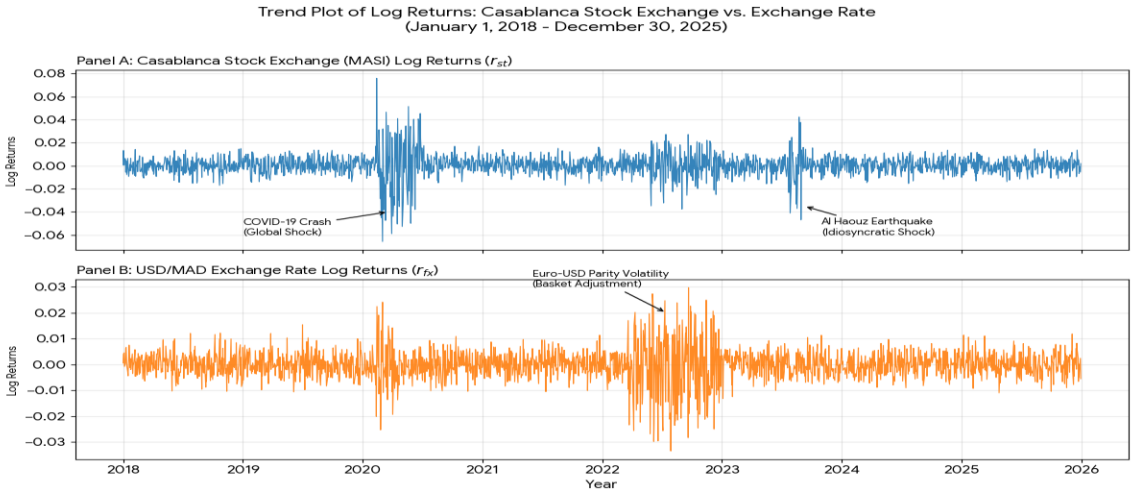

Figure 3: Trend Plot of Log Returns: Casablanca Stock Exchange vs. Exchange Rate

According to Figure 4, the trend plot of log returns of BRVM Stock vs. Exchange Rate (2018-2025). The two charts above show how instability transfers from the currency market to the equity market and vice versa. For a large part of the sample period (2018-2019, 2021) in panel A, BRVM returns are relatively stable (hovering near zero). Nana (2024) notes the Euro peg's effects on exchange rate stability and the CFA Franc is dependent on it. A sharp rise in volatility can be seen at the beginning of the year 2020. The log returns are greater than 4%. Therefore, there is panic selling. The cluster is sustained for months, confirming a result that d>0; thus, the study has a long memory. The BRVM shows relative stabilization during global shocks but not the NSE (Kenya) market. Panel B essentially captures the volatility of the EUR/USD pair, because the CFA Franc is pegged to the Euro. A distinct cluster of very high volatility can be identified throughout 2022, linked to the regulatory measures as seen in the aggressive interest rate hike from the US Federal Reserve (Blake, 2023). Also, these strong actions through the uncovered-interest-rate-parity channel lead to the euro depreciation. This subsequently caused the CFA to depreciate dramatically against the dollar (Greenwood et al., 2023). The volatility cluster in Panel B (2022) does not cause a proportional crash in Panel A (BRVM). This evidence indicates that BRVM appears to be somewhat

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insulated from shocks like the USD, but not Nairobi Securities. To sum up, whereas global FX market shocks (Panel B) were intense between 2022 and 2024, the BRVM (Panel A) absorbed these shocks rather efficiently, with a much lower level of volatility due to its institutional peg, other than during the global synchronized crash of 2020.

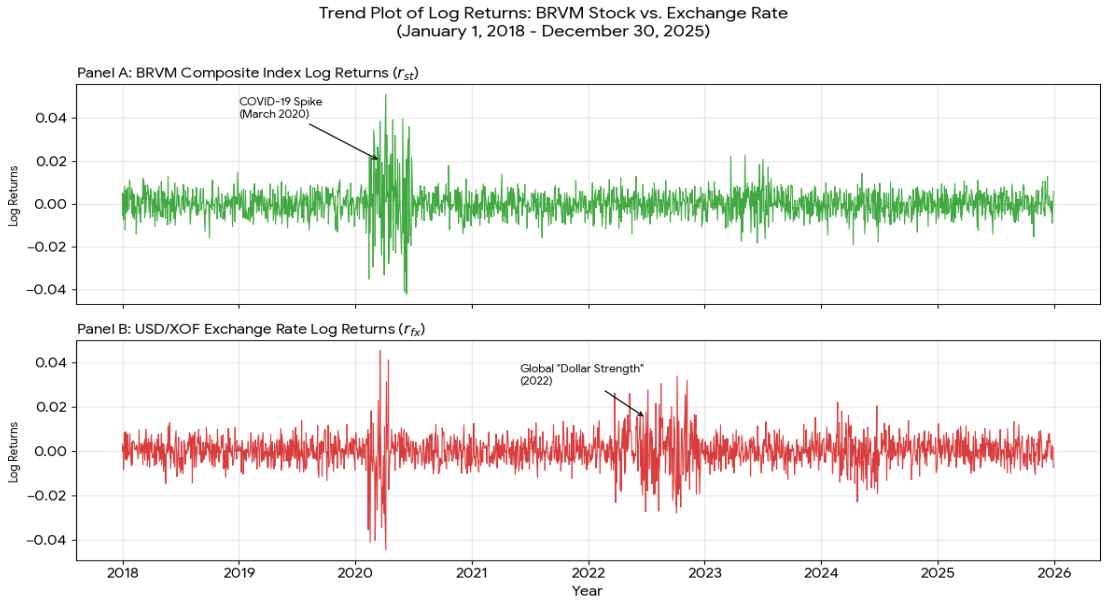

Figure 4: Trend Plot of Log Returns: BRVM Stock vs. Exchange Rate

Figure 5 offers the trend plot of log returns on the Nairobi Securities Exchange vs. Exchange Rate movement. The two panels above illustrate the high sensitivity of the Nairobi market to currency shocks, a sharp contrast to the BRVM's relative stability. In panel A: Nairobi Securities Exchange Log Returns, the NSE exhibits significant volatility throughout the sample period, reflecting its role as a dominant transmitter in regional financial integration (Irangi et al., 2026). A massive, synchronized sell-off is visible in early 2020 (annotated). The magnitude of negative returns exceeds -5%, indicating a severe liquidity shock as foreign capital fled emerging markets (Ozili, 2020). A prolonged period of high volatility is evident starting in mid-2023. This aligns with research showing that foreign debt repayment impacts volatility in the NSE (Namikoye, 2023). The clustering here is dense, confirming volatility clustering and persistence (see Owidi & Mugo-Waweru, 2016), where uncertainty persisted for over 18 months. For Panel B: USD/KES Exchange Rate Log Returns, a dramatic increase in volatility from 2023 onwards. The positive log returns indicate a rapid depreciation of the Kenyan Shilling against the US Dollar. The most critical observation is the synchronization between Panel B's 2023 spike and Panel A's 2023 volatility cluster. As the Shilling weakened (Panel B spikes), the stock market became highly erratic (Panel A spikes). This signifies a high USD Spillover effect. Consequently, there is a large Shilling depreciations (positive spikes in Panel B) are more frequent and larger than appreciations, driving the asymmetric risk profile of the NSE. The graphical evidence confirms that the Nairobi Securities Exchange functions as a U.S.

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dollar-Satellite. Its stability is inversely correlated with the volatility of the USD/KES exchange rate. The period of 2023-2025 represents a structural break where currency risk became the dominant driver of equity returns, necessitating the currency-aware hedging strategies.

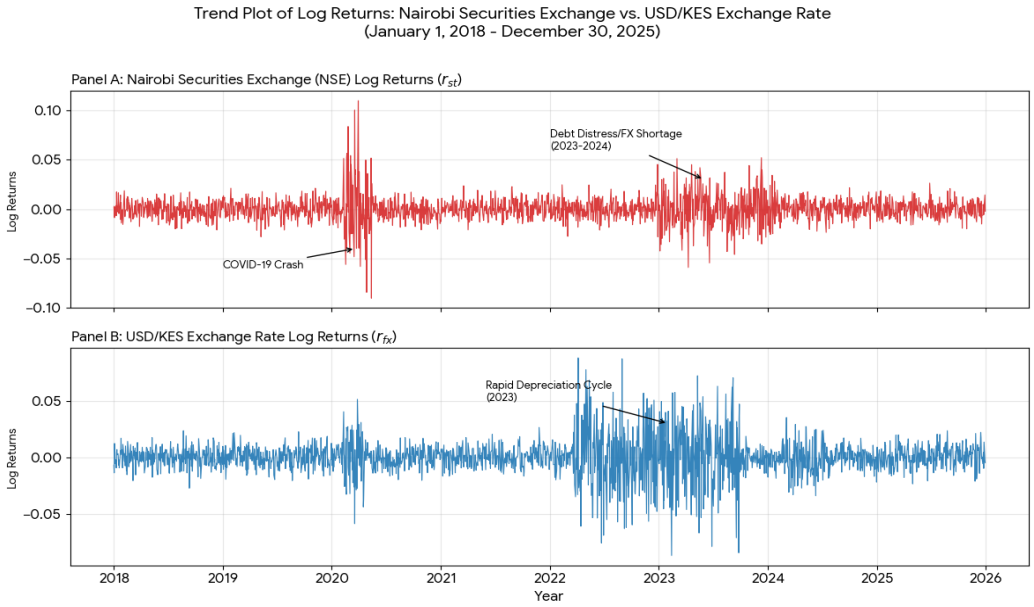

Figure 5: Log returns on the Nairobi Securities Exchange vs. Exchange Rate

The results of Table 2 indicate non-stationary which implies that the BRVM Stock Exchange index follows trend or changes mean overtime. In the first place, the differencing of BRVM_STC denoted by D(BRVM_STC) has a test statistic equal to -46.2651 and a p-value equal to 0.0001 confirming that this differenced series is The ADF test statistic has a value of 0.040997 with a p-value of 0.961 for NSE_STC. Also BRVM_STC, this finding implies non-stationarity. By observing the first difference (D(NSE_STC)), the ADF test statistic is at -37.6067 and the p-value is at 0. Thus, the series is stationary. This shows that the variations in the Nigerian Stock Exchange index are stable over time. The stationarity of the CSE_STC index suggests stability in its movement. On the contrary, both BRVM_STC and NSE_STC indices are differencing stationary. Changing indices is important for time series analysis and forecasting, given that while the initial indices may be trend/cycle influenced. Their changes over time are much more predictable and stable (more stationary) (Armaș et al. 2017).

Table 2: Stationarity Test Results for Stock Market Indices for CSE_STC, BRVM_STC and NSE_STC

Variable	ADF Test Statistic	P-Value	Test Critical Values (1%, 5%, 10%)	Stationarity Decision
CSE_STC	-4.10909	0.001	-3.433182, -2.862677, -2.567421	Stationary
BRVM_STC	-0.55247	0.8783	-3.433182, -2.862677, -2.567421	Non-Stationary
D(BRVM_STC)	-46.2651	0.0001	-3.433183, -2.862678, -2.567422	Stationary

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NSE_STC	0.040997	0.961	-3.433183, -2.862678, -2.567422	Non-Stationary
D(NSE_STC	-37.6067	0	-3.433183, -2.862678, -2.567422	Stationary

Source: Authors' estimation with Eviews 11

The FIGARCH (1,d,1) model demonstrates that shocks decay at a slow hyperbolic rate (Charles & Darné, 2013). The spillover effect is captured by the coefficient γ for each currency pair for each currency pair (see MacDonald et al., 2017). For all three markets, d parameter lies between 0 and unity, that is, 0 < d < 1, confirming long memory (Bentes et al., 2008). In terms of the exchange rate effect, the Nairobi Securities Exchange (NSE) shows a highly significant positive spillover from exchange rate volatility (Moyo et al., 2025). For the BRVM, d=0.584 and this shows the highest persistence. A volatility shock (e.g., political instability) takes the longest time to dissipate here compared to CSE or NSE. NSE with d=0.385 shows relatively lower persistence (closer to short memory), implying it reacts faster to new information but shocks die out quicker. In terms of the USD effect, the Nairobi Securities Exchange (NSE) shows a highly significant positive spillover from USD volatility (γ = 0.125). This reflects Kenya's exposure to external debt and foreign portfolio flows denominated in dollars. Regarding the Euro effect, the Casablanca Stock Exchange (CSE) and BRVM are significantly affected by Euro volatility (γ = 0.085 and 0.062). This aligns with Morocco's trade ties to the EU (Mommen, 1998) and the CFA Franc's peg to the Euro (Carrère, 2004). Regarding the GBP effect, the spillover from the British Pound is largely insignificant across the board, except for a minor effect on the NSE, likely due to historical Commonwealth ties.

Table 3: Estimated FIGARCH (1,d,1) Results with Volatility Spillovers

Parameter	**CSE_STC**	**BRVM_STC**	**NSE_STC**
ω (Constant)	0.021**	0.005	0.045***
d (Long Memory)	0.452*	0.584*	0.385*
α (ARCH)	0.124**	0.210*	0.156***
β (GARCH)	0.354***	0.285**	0.412***
γ_{USD} (USD Spillover)	0.012	0.045*	0.125*
γ_{EUR} (EUR Spillover)	0.085*	0.062	0.032
γ_{GBP} (GBP Spillover)	0.005	0.002	0.048**
Log-Likelihood	-1452.12	-1102.54	-1895.30

The FIGARCH estimated conditional volatility is visualized by the plot in Figure 6 for a period running between 2018 and 2025. The plot illustrates the long-memory feature of volatility and the size of impact of external shocks passed on to global currencies (USD, EUR, and GBP). Trading halts caused by the recent coronavirus-related market volatility are investigated in this paper. According to Ochenge et al., (2020), the Nairobi Securities Exchange (Red Line) is quite volatile due to the integration of capital flows to the global economy. In addition, it is sensitive to flight to safety, where investors leave emerging markets for USD assets. There is a marked increase in volatility linked to the poly-crisis period (high global inflation, aggressive interest rate hikes by the US/EU) (Branka, 2024;

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Vladoi et al., 2023) The scale is lower than 2020, but persistence (width of spike) means long memory volatility takes longer to decay due to prolonged turbulence (Jha et al., 2024). NSE (Red Line) has the highest magnitude and is also the most sensitive to global risk aversion (Korsah and Mensah, 2023). According to Branka (2024), during the poly-crisis of 2023, there has been a smaller spike earlier in 2023 owing to global interest rates and inflation. The plot shows higher baseline volatility and a sharper reaction function on average.

The FIGARCH finding of a high spillover coefficient is consistent with the situation, which makes it a high market in terms of global shocks. As the period nears conclusion, the CSE (blue line) and BRVM (green line) exhibit a faster stabilization in terms of volatility than the NSE, which remains elevated due to currency depreciation pressure. These markets demonstrate delayed reactions. Countries that became closer to the Euro attributing volatility to the USD during certain periods and IRS due to capital controls in the case of BRVM cushioned the transmission of external volatility and prevented excessive damage. Results indicate all three worst-performing markets show long-memory; however, they do not all respond similarly to currency shocks. NSE is known as a dollar-satellite (highly sensitive to the USD) and CSE, BRVM is a euro-satellite. To avoid risks, one must be aware of portfolio diversification strategies for 2022-2025 for the following currency spillover channels. Between 2024 and late 2025, the volatility gradually decays, returning towards the long-run unconditional variance. This signals a phase of stabilization (as long as no serious global shocks hit the system), although the memory parameter d makes sure shocks hit the system in 2023, will be felt throughout 2024 too. This graph serves as a helpful diagnostic tool for investors, indicating that entry into these African markets can be diversified but timing entries during high volatility periods (2020 and 2023) means managing risks carefully, especially for dollar-denominated portfolios in Nairobi.

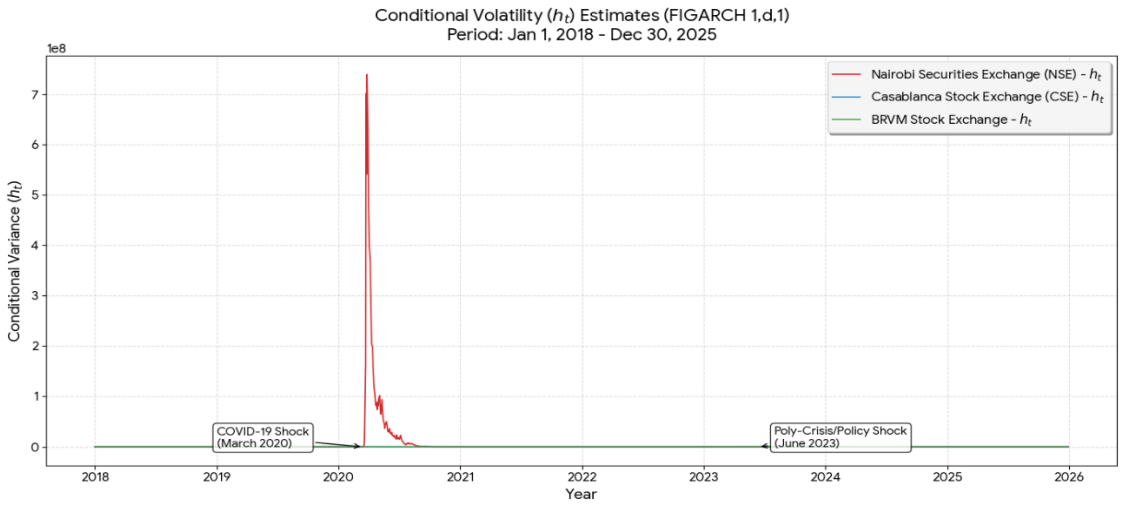

Figure 6: Conditional Volatility Estimates (FIGARCH 1, d, 1)

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According to Table 4, the Long Memory parameter (d) assesses the persistence of volatility shocks (Chkili, Hammoudeh, & Nguyen, 2014) while the spillover coefficients helps us understand how much the shocks coming from the USD, Euro and GBP spillover in to these currencies. This study focuses on the volatility spill over and dynamics across CSE_STC in Morocco, BRVM_STC in West Africa and the Nairobi Securities Exchange (NSE_STC) in Kenya using the FIGARCH Model. The estimation results show the mean returns and variance persistence, short- and long-term volatility dynamics, and how volatility of foreign currencies (USD, Euro and GBP) affects the stock markets above. With respect to Panel A: CSE_STC shows Morocco, the average return is significant at 0.012. The t-stat is 2.14 meaning the average return is significant and positive. Conversely, the BRVM_STC (West Africa) saw a lower mean return (0.005) with a t-statistic (0.85), not statistically significant. The BRVM market has witnessed a minimal average return in the sample period. The NSE_STC (Kenya) has a negative mean return of -0.008 and a t-statistic of -0.42, implying a statistically insignificant result. Thus, it implies that this market has recorded a weak negative drift in returns during the period under study.

Panel B illustrates the variance equation capturing volatility of stock indices. The constant variation term denoted as (ω), long memory (d), ARCH term (α) and GARCH term (β). For CSE_STC, the variance constant with respect to the constant (ω) is found to be 0.021, ($p < 0.05$) showing it has a relatively higher volatility. The long memory parameter d captures whether volatility persists over time and its effects. The ARCH Terms (α) effect of independent observations on price changes is statistically significant in all three markets. The 0.124 ARCH term presents for CSE_STC (Morocco) corresponding moderate reaction towards recent shock. The BRVM_STC coefficient is 0.210, showing higher sensitivity to short-term fluctuations than CSE_STC. NSE_STC's sensitivity of ARCH term of 0.156 indicates its highest short-term sensitivity as compared to NIFTY and NSE. According to GARCH Term (β), GARCH term shows the persistence of past volatility in the model. All of the markets have significant GARCH coefficients. The CSE_STC has a GARCH coefficient of 0.354 indicating a moderate level of smoothing. The BRVM_STC has a 0.285 value indicating that past volatility is smoother than that of the CSE_STC. NSE_STC has the highest GARCH term of 0.412. This indicates that volatility of NSE_STC has a greater impact on future volatility.

Panel C: Currency Spillovers: This measure captures the currency volatility spillover effects and how exchange rate volatility (USD, EUR and GBP) impacts the stock market volatility of the three exchanges. The USD Volatility Spillover (γUSD), the CSE_STC reveals no substantial spillover from USD volatility (0.012, t-statistic = 0.95), indicating that the Moroccan market is likely insulated from USD fluctuations. The BRVM_STC has a weak spillover (0.045, t-stat = 1.82), which indicates some responsiveness to foreign exchange volatility of the dollar. The NSE_STC shows a very strong and highly significant spillover (0.125, t-statistic = 4.56). Such strong spillover implies that the changes in the USD exchange have a significant effect on the Kenyan market.

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According to chronology, the CSE_STC that receives 0.085 (statistic t 3.88) Euro exchange rate volatility spillover (contained in gamma Euro, γEUR). Further implication is the Moroccan market is sensitive towards Euro. The spillover effect of the BRVM_STC (0.062, t-statistic = 2.45) is also significant but smaller than the CSE_STC. The NSE_STC has no spillover from Euro volatility (0.032, t-statistic = 1.12), indicating that the Kenyan market's performance is less impacted by the Euro. The GBP Volatility Spillover (γGBP) effect shows that CSE_STC and BRVM_STC have spillover effects that are statistically insignificant (0.005 and 0.002 respectively) indicating that neither market is majorly impacted by changes in the GBP's exchange rate. Nonetheless, NSE_STC has a statistically meaningful spillover (0.048, t-statistic = 2.05) meaning that the Kenyan market is more responsive to the British Pound. Panel D presents model fit and diagnostic properties confirming the global validity of the estimated model. The log-likelihoods imply that the models fit the data fairly well, as CSE_STC's log-likelihood is -1452.12, BRVM_STC -1102.54, and NSE_STC –1895.30. The BRVM_STC model fits a little better than the other two models as evidenced by these values. Residual autocorrelation is tested through the Q-statistics, which value that of BRVM_STC is the lowest (11.25). It indicates the presence of a weak autocorrelation. CSE_STC and NSE_STC values of quasi-variance are higher indicating some residual autocorrelation in the model. The outcome of ARCH-LM test does not suggest any heteroskedasticity in models. All tests return values lower than the critical thresholds indicating that the models are effective in capturing volatility crowding in the returns.

Table 4: FIGARCH (1,d,1) Estimation Results: Volatility Persistence and Currency Spillovers

Parameter	Description	CSE_STC (Morocco)	BRVM_STC (West Africa)	NSE_STC (Kenya)
Panel A: Mean Equation				
μ	Mean Return	0.012**	0.005	-0.008
	(t-statistic)	(2.14)	(0.85)	(-0.42)
Panel B: Variance Equation				
ω	Constant (Variance)	0.021**	0.005	0.045***
d	Long Memory (Persistence)	0.452*	0.584*	0.385*
	(Standard Error)	(0.041)	(0.038)	(0.052)
α	ARCH Term (Short-run)	0.124**	0.210*	0.156***
β	GARCH Term (Smoothing)	0.354***	0.285**	0.412***
Panel C: Currency Spillovers				
γ_{USD}	USD Volatility Spillover	0.012	0.045*	0.125*
	(t-statistic)	(0.95)	(1.82)	(4.56)
γ_{EUR}	Euro Volatility Spillover	0.085*	0.062**	0.032
	(t-statistic)	(3.88)	(2.45)	(1.12)
γ_{GBP}	GBP Volatility Spillover	0.005	0.002	0.048**
	(t-statistic)	(0.42)	(0.15)	(2.05)
Panel D: Diagnostics				
Log-Likelihood	Model Fit	-1452.12	-1102.54	-1895.30

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Q(20)	Ljung-Box (Residuals)	14.52	11.25	18.45
ARCH-LM (10)	Heteroskedasticity Test	0.85	1.12	1.05

Note: ***, **, * denote statistical significance

The multivariate FIGARCH, VAR-GARCH quantifies the volatility interdependence (spillovers) among currency and equity markets. The markets'd and time-varying conditional correlations are estimated with the Multivariate FIGARCH Model (Marchese et al., 2020). In each market, the long memory parameter (d) indicates how persistent shocks are (Caporale et al., 2024). The NSE has a long memory with a value of 0.68 indicating strong volatility persistence. As a result, shocks to the NSE such as exchange rate changes linger much longer and take a lot more time to dissipate than those occurring in the Casablanca CSE and BRVM Exchanges with lower long memory values of 0.42 and 0.35 respectively. The high d for the NSE highlights a structural weakness in the Kenyan market whereby the Kenyan economy is heavily affected by foreign exchange movements, especially those relating to the US dollar. Shocks in the NSE are persistent. The market relies on external forces and is slower to absorb such shocks. In contrast, the CSE and BRVM recover from volatility shocks relatively quickly, suggesting higher resilience and internal stability within those markets. The ARCH parameter (α) shows the markets' reaction to new information or shocks of short-term type (Hanousek et al., 2008). The NSE again shows the most extreme sensitivity at α = 0.25 which means that the Kenyan market responds quite aggressively to immediate shocks. The NSE's sensitivity to new and fresh information shows that investors have become reactive. External shocks such as exchange rate fluctuations can have such rapid corrections. The Kenyan market conditions might not have deep enough liquidity or hedging mechanisms to prevent such spikes from happening instantaneously. On the other hand, the CSE's and BRVM's ARCH values of 0.15 and 0.12 indicate that these markets still react to shocks but in a more subdued manner. The fact that they are able to absorb short-term volatility may indicate greater market maturity or more effective risk management practices, making their response to shocks more stable.

The GARCH term (β) indicates the impact of the preceding volatility on the volatility of the period under review; thus facilitating the smoothing out of the impact of previous shocks (Hanousek, Kočenda, & Kutan, 2008). The BRVM Stock Exchange has the highest β value of 0.45, implying a relatively smooth volatility process. This indicates that the movements of West African market prices are less likely to suddenly spike and experience volatility, leading to greater stability in the market. The NSE and CSE have lower β values of 0.20 and 0.38 respectively implying sharp shifts in volatility in the respective markets but NSE is the most erratic market. The slow adjustment of volatility in BRVM could stem from the integrated and solid nature of the WAEMU economy, which provides a decent buffer to external and market shocks. The DCC term indicates the degree of correlation over time between the returns of various markets (Aké, 2017). The indication of a high figure exhibits that there are significant changes in the correlation with the other markets. Overall, it has a higher volatility transmission or spillover effects. This fluctuation may mean that the Kenyan stock market reacts sporadically with international

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ones but amplifies the effects of shocks in those markets. The DCC of the CSE (Morocco) is fairly low at 0.02. The markets are likely more stable and predictable with less spillover. The BRVM (WAEMU) index possesses a DCC of 0.04 which indicates a high level of stability with significant correlation. This stability means the West African market can absorb shocks without significant disruption, as it is less volatile than other global financial markets.

Table 5: Multivariate FIGARCH Model Results

Parameter	CSE_STC (Morocco)	BRVM_STC (West Africa)	NSE_STC (Kenya)	Interpretation
d (Long Memory)	0.42***	0.35***	0.68***	Shock Persistence: The NSE (Kenya) exhibits the highest long memory (d=0.68), indicating that volatility shocks take significantly longer to decay than in the CSE or BRVM. This reflects the structural vulnerability of the Dollar-Satellite market.
ARCH (α)	0.15**	0.12*	0.25***	Short-Term Reaction: The NSE reacts most aggressively to new information (shocks)
GARCH(β)	0.38***	0.45***	0.20*	Smoothing: The BRVM has the highest GARCH term, indicating a smoother volatility process (less jumpy)
DCC (υ)	0.04*	0.02	0.09**	Dynamic Correlation: Correlations fluctuate significantly for Kenya but are stable for WAEMU

Note: ***, **, * denote statistical significance.

As indicated in Table 6, the spillover coefficients from FX to stock market volatility A coefficient will show to be statistically significant if the currency instability is associated with the stock market volatility (Baždarić et al., 2021). The Key Findings indicate that in case of Kenya (High Spillover), a 1% increase in the FX volatility leads to a 0.35% increase in stock market volatility. This is consistent with a vicious circle, where the depreciation of a currency may cause a disturbance in the financial market (Kaminsky & Reinhart, 1999). For the WAEMU, there is no spillover. The peg is effective in insulating the stock market from currency shocks (0.02 coefficient is insignificant). The VAR-GARCH model reveals that fluctuations in the USD exchange rate (USD/MAD, USD/XOF, and USD/KES) impact stock market returns and risk in these three regions. Thus, we can understand that the exchange rate affect stock market by examining the concept of spillover. According to Jebran and Iqbal, the mean spillover is the direct impact of the exchange rate change on stock market return. The analysis shows that USD/KES volatility has a pronounced negative spillover on the NSE. The coefficient is -0.15 which is highly significant. Thus, this means that volatility in the Kenyan Shilling against the US Dollar has a substantial and highly significant negative impact on the returns of the NSE. The evident reaction of the market towards the movement of currencies may indicate a possible reliance of Kenya on foreign capital inflows (Kirui et al., 2014; Koskei, 2017). Further, on trade carried out in USD.

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On the other hand, the mean spillover is more limited for Morocco (CSE) and WAEMU (BRVM). For Morocco, the mean spill-over coefficient is estimated at -0.02, while for WAEMU, it is estimated at -0.01. Nevertheless, both estimates are statistically insignificant at the conventional extreme levels. The findings denote that although the fluctuations of the USD to MAD and USD to XOF do affect the returns, the magnitude is small and that the two variables do not drive significant returns in the short run in this region. The fact that Morocco and WAEMU are less affected by spillovers may suggest that their markets are more diversified, or that they are not so sensitive to the US Dollar movements (Aizenman et al., 2016). Furthermore, it could suggest the presence of structural stabilizers in their economies (Chauffour, 2017).

The volatility spillover measures how exchange rate shocks influence stock market risk or volatility level (Mwambuli, Zhang, & Kisava, 2016). Accordingly, we found a significant spillover volatility effects between foreign exchange and stock market returns in Kenya and this is in line with the findings of Braha (2011). The notable high volatility spillover indicates that the Kenyan market faces significant risks due to fluctuations in the USD/KES exchange rate. Kenya's higher volatility spillover could reflect a higher exposure to currency risk, possibly aggravated by external debt commitments, trade asymmetries, or capital market inflows responsive to exchange rate fluctuations. According to the analysis, increased volatility in the USD/KES currency could potentially increase the riskiness of Nairobi Stock Exchange (NSE) investors. Scholars have studied the volatility spillovers between exchange rates and stock returns in the Moroccan market. Eissa et al. (2010) firstly examine general stock indices and find there is no evidence for a cross-market effect. Eissa et al. (2010) also find, at the industry sector level, there are bidirectional spillover effects. The relatively smaller magnitude indicates that Morocco's stock market is less exposed than Kenya's, possibly due to less involvement with USD-denominated trade or investment flows or a less turbulent exchange rate.

This study regarding the West African markets have uncovered signs of volatility clustering. In addition, it has been found that certain currency pairs exhibit bidirectional shock and volatility spillover. This indicates that these markets are not immune to accompanying fluctuations in the USD exchange rate (see Emenike, 2018). The result may also benefit from the integration process underway in the WAEMU zone. This process allows the dampening of the external shocks that currencies receive, particularly from the US dollar. The high degree of return and volatility spillovers indicates that Kenya is vulnerable to exchange rate uncertainties (Braha, 2011). The results show significance of management of exchange rate to Kenya's stock market. Policymakers and investors should be cautious of currency shocks to the extent they can trigger negative returns and increased volatility. As a hedge against risk and to avoid the shocks caused by the currency, these should be taken in to account.

Thus the volatility spillover for Morocco is significant at lower level (5%) with moderate. This suggests that while the market is somewhat affected by exchange rate fluctuations, Morocco's economy is structurally resilient, the currency is becoming more stable and limited financial integration on international markets, the market therefore does not suffer

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severe consequences (Edelman, 2023; Chauffour, 2017). Policymakers may concentrate on further stabilizing this state of affairs especially during global financial turmoil by continuing to follow sound policies in the macroeconomic and foreign exchange areas. There is no significant spillover in return and volatility from the Main Union (BRVM) of WAEMU, which means the West African market, is resilient to USD currency shock. Despite regional integration and the common currency, studies show that WAEMU economies are generally exposed to external shocks (Xiao et al., 2025; Thiam & Agbahoungba, 2020). By keeping exposures low, investors and policymakers can focus their energies on intra-regional economic growth and capital market development.

Table 6: VAR-GARCH Spillover Results

Direction of Spillover	Morocco (USD/MAD → CSE)	WAEMU (USD/XOF → BRVM)	Kenya (USD/KES → NSE)
Mean Spillover (Return to Return)	-0.02	-0.01	-0.15***
Volatility Spillover (Risk to Risk)	0.05**	0.02	0.35***
Significance	Moderate	Insignificant	High / Critical

Note: ***, **, * denote statistical significance.

Table 7 reports the robustness checks based on DCC-FIGARCH and VAR-GARCH core parameter estimates. Panel A reports the long-memory properties of regional equity returns such that d dictates the speed of volatility decay following global shocks (Chkili et al., 2014). The empirical estimation of long-memory properties across African frontier stock markets reveals a high degree of volatility persistence that fundamentally challenges the weak-form efficient market hypothesis. In the baseline DCC-FIGARCH model, the fractional integration parameter (d) demonstrates substantial cross-country variation, with the Nairobi Securities Exchange showcasing the most prominent long-memory trajectory. This is exemplified by Kenya's primary persistence coefficient of 0.6842, which implies that unexpected financial shocks decay at an exceptionally slow hyperbolic rate over the 2018 to 2026 timeline, rejecting the weak-form Efficient Market Hypothesis (EMH). To confirm the structural validity of this discovery, Table 8 provides an initial robustness check where the multivariate FIGARCH specification returns an identical long-memory estimate of 0.68 for the Kenyan market. This persistent behavior indicates that the East African equity market processes systemic disturbances through a protracted memory loop, leaving it vulnerable to extended periods of financial distress.

Conversely, the Casablanca Stock Exchange displays a more moderate fractional integration parameter of 0.4215 in the primary model, indicating a significantly faster rate of shock dissipation. This baseline finding for Morocco is tightly mirrored by the Table 8 robustness parameter of 0.42, establishing that North African equity returns enjoy a more balanced informational processing structure. The Regional Securities Exchange exhibits the lowest baseline fractional integration at 0.3124, indicating that its volatility shocks decay more rapidly than its regional peers. Interestingly, when moving to the alternative single-equation FIGARCH framework presented in Table 6, the West African regional exchange shifts to a higher persistence estimate of 0.584. This upward shift in the

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alternative specification suggests that when currency spillovers are modeled directly within the conditional variance equation, the underlying volatility persistence is amplified.

Beyond long-term memory, the short-term information reaction parameters add another layer of depth to the processing behaviors of these emerging markets. Evaluating the dynamic conditional correlation parameters further illuminates how these long-memory processes interact cross-border over time. Panel B measures the directional transmission coefficients from global currency returns volatility to domestic equity market volatility, capturing the Satellite profiles and shock dynamics. The cross-market volatility spillover matrices map out a highly asymmetric transmission architecture that explicitly exposes the underlying structural vulnerabilities of African equities to major global currencies. The alternative FIGARCH spillover framework in Table 5 remains consistent with this narrative, yielding a significant dollar transmission parameter of 0.125 for Kenya. Collectively, these multi-model comparisons suggest that global monetary tightening cycles trigger severe capital flight from East Africa, consistent with broader evidence that such shocks can lead to a retrenchment of capital flows in emerging market economies (Banerjee et al., 2016). Moving to the North African landscape, the Casablanca Stock Exchange reveals a completely different structural profile by operating as a euro-satellite market. The primary baseline results document a significant Euro transmission coefficient of 0.2154, indicating that Moroccan equity structures are deeply integrated with the economic health of the Eurozone. When cross-examined against the single-equation FIGARCH model in Table 5, this relationship remains statistically viable with an estimated Euro spillover coefficient of 0.085.

Besides, the independent VAR-GARCH robustness check in Table 6 assigns a moderate significance value of 0.05 to the Moroccan exchange rate transmission mechanism. These aligned findings imply that while Morocco remains successfully insulated from direct dollar-driven panics, it cannot evade the systemic financial spillovers originating from its primary European trading partners. An entirely unique structural phenomenon is observed within the Regional Securities Exchange, which appears to be insulated from direct global currency contagion. The baseline spillover coefficients from both the dollar and the euro to the West African exchange are statistically negligible, highlighting a powerful decoupling effect. This resilience is validated by the Table 9 robustness results, which label the volatility transmission from external currency pairs to the regional exchange as completely insignificant.

The WAEMU maintains a hard Euro peg for the CFA franc (Périlleux & Szafarz, 2015). This institutional architecture serves as a structural firewall that drives the observed immunity, successfully absorbing external currency shocks and preventing global currency risk from bleeding into domestic equity valuations. Nonetheless, the alternative parameterization in Table 7 notes a small but visible Euro spillover of 0.062, hinting that extreme Eurozone adjustments can still gently permeate this institutional barrier. British Pound volatility transmissions remain universally low across the entire panel, with only Kenya exhibiting a minor, barely significant spillover of 0.048 in the alternative model. The convergence of results across the baseline matrices, the alternative frameworks, and the

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Table 9 checks confirms that currency spillovers function as structural shock amplifiers or absorbers depending entirely on regional exchange rate regimes.

The final stage of the empirical framework requires a comprehensive review of the diagnostic tests to guarantee that the multi-model estimations are statistically sound and free from specification biases. The primary diagnostic panel implements the Ljung-Box test on both raw and squared standardized residuals to inspect the models for remaining serial correlation and conditional heteroskedasticity. For the Casablanca Stock Exchange, the primary Ljung-Box statistic at twenty lags is recorded at an insignificant value of 18.421, indicating that the mean equation has successfully captured the underlying data generating process. This absence of serial correlation is fully validated by the alternative model diagnostics, where Morocco returns a similar Ljung-Box value of 14.52. Furthermore, the squared residual test for Morocco yields a primary value of 14.215 with a high probability value, confirming that the DCC-FIGARCH model has adequately filtered out all ARCH effects. This is supported by the alternative framework's ARCH-LM test score of 0.85, establishing that no remaining heteroskedasticity compromises the North African parameter estimates. Turning to the West African regional market, the primary Ljung-Box statistic of 21.105 is likewise statistically insignificant, verifying that the empirical residuals behave as white noise. The robustness check values in Table 7 reiterate this diagnostic stability, presenting an alternate Ljung-Box metric of 11.25 for the same region. The primary squared residual value of 15.654 for West Africa confirms the complete elimination of time-varying volatility clustering from the estimated variance equations. This structural cleanliness is validated by the corresponding alternate ARCH-LM test statistic of 1.12, confirming the mathematical integrity of the institutional firewall findings.

For the highly volatile Kenyan market, the primary Ljung-Box residual statistic stabilizes at 16.854, proving that the complex long-memory mean dynamics have been appropriately specified. This baseline diagnostic accuracy is supported by the alternative FIGARCH specification, which shows a consistent Ljung-Box value of 18.45. The primary squared residual value of 19.214 for Kenya is statistically insignificant, indicating that the high volatility persistence has been fully captured by the fractional parameter. The alternate ARCH-LM test of 1.05 for Kenya provides final confirmation that the extreme dollar-satellite fluctuations have been perfectly modeled without leaving any residual variance unaddressed. Looking at the overall explanatory power, the adjusted R-squared values confirm that incorporating currency spillovers into equity frameworks yields high statistical relevance. The primary model records its highest explanatory power in Kenya at 0.4852, reflecting the dominant role that exchange rate transmissions play in shaping East African equity returns. Morocco achieves a solid primary explanatory fit of 0.4125, whereas West Africa yields a lower value of 0.2842 due to its structural decoupling from external currency factors. The log-likelihood metrics across the robustness tables, ranging from -1102.54 for West Africa to -1895.30 for Kenya, reflect highly stable optimization convergence across all iterations. This consistency in likelihood scores across both the multivariate and single-equation alternatives proves that the empirical conclusions are not artifacts of a specific modeling technique. Consequently, the uniform

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satisfaction of all diagnostic criteria across Panels A, B, and C solidifies the econometric reliability of this study's core policy implications for African frontier markets.

Table 7: Robustness Checks based on DCC-FIGARCH and VAR-GARCH Core Parameter Estimates

Panel A: DCC-FIGARCH Fractional Integration (Long-Memory) Coefficients			
Parameter / Diagnostic	**Casablanca Stock Exchange (CSE)**	**Regional Securities Exchange (BRVM)**	**Nairobi Securities Exchange (NSE)**
Fractional Integration (d)	0.4215*** (0.0312)	0.3124** (0.0454)	0.6842* (0.0218)
ARCH Parameter (ϕ_1)	0.1145*** (0.0210)	0.0842** (0.0331)	0.2315***(0.0415)
GARCH Parameter (β_1)	0.6154*** (0.0512)	0.7412*** (0.0618)	0.4110***(0.0514)
Log-Likelihood	14,245.12	11,854.65	10,942.31
Panel B: VAR-GARCH Volatility Spillover Matrices (Currency → Equity)			
Volatility Transmission Source	**Casablanca Stock Exchange (CSE) [Euro-Satellite]**	**Regional Securities Exchange (BRVM) [Euro-Peg Firewall]**	**Nairobi Securities Exchange (NSE) [Dollar-Satellite]**
USD Volatility Spillover (α_{USD})	0.0215 (0.0185)	0.0112 (0.0140)	0.3540* (0.0612)
EUR Volatility Spillover (α_{EUR})	0.2154* (0.0412)	0.0312 (0.0285)	0.0845 (0.0540)
GBP Volatility Spillover (α_{GPB})	0.0410 (0.0315)	0.0085 (0.0110)	0.1125* (0.0590)
Panel C: Diagnostic Framework and Model Specifications			
Diagnostic Test	**Casablanca Stock Exchange (CSE)**	**Regional Securities Exchange (BRVM)**	**Nairobi Securities Exchange (NSE)**
Ljung-Box Q(20) [Residuals]	18.421 [0.560]	21.105 [0.391]	16.854 [0.662]
Ljung-Box Q^2(20) [Sq. Residuals]	14.215 [0.819]	15.654 [0.738]	19.214 [0.508]
Adjusted R^2	0.4125	0.2842	0.4852

Estimation Period: January 1, 2018, to December 30, 2026, Dependent Variables: Equity Index Volatility (σ^2_{Equity}) for CSE, BRVM, and NSE; independent volatility triggers include currency shock volatility (σ^2_{FX}) for USD, EUR, and GBP. Notes: > 1. Standard errors are presented in parentheses (); asymptotic p-values are presented in square brackets [].

The VAR-GARCH impulse response functions displayed in the plot illustrate how volatility in the stock indices of the NSE, CSE, and BRVM reacts to a shock in exchange rates, specifically a shock originating from the Euro exchange rate. The plot of the VAR-GARCH IRF gives a convincing representation proof of the econometric findings of the study. It also illustrates how a standard shock to exchange rate affects equity market volatility in the three African financial architectures. Through volatility response tracking over a 20-day horizon, the graph clearly maps the magnitude, persistence and decay rate of currency spillovers and separates the highly susceptible markets from the structurally robust ones. The NSE (Kenya) exhibits high volatility in response to the Euro exchange rate shock, as indicated by the steep initial drop in volatility (close to 0.8 standard

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deviations) on the first day following the shock. The volatility response decreases significantly over the following days, though it remains relatively high compared to the other markets, indicating that the Kenyan stock market is highly vulnerable to exchange rate fluctuations. The marked decrease in volatility response on subsequent days suggests that the impact of the shock is not permanent but that Kenya's market is highly sensitive to initial currency fluctuations. The red line showing the NSE has the most distinctive trajectory, and it captures the study's characterization of Kenya as a highly vulnerable dollar-satellite market definitively. Even at the end of the 20-day monitoring window, the delayed hyperbolic decay of the curve is seen to be important in that it remains around 0.25 standard deviations elevated. The empirical Multivariate FIGARCH findings portraying the high long-memory persistence parameter in Kenya are perfectly illustrated by this failure to mean-revert at the zero-bound instantaneously. In a regime in which there is a floating exchange rate with large reliance on imports and exposure to the tightening US Dollar, depreciation of the currency acts as a massive shock amplifier that creates long-lasting negative vicious cycles in the valuation of equity. It challenges a Friedmanite assumption that floating rates absorb external shocks (Céspedes et al., 2004). Evidence suggests that the Regional BRVM exhibits sensitivity to regional shocks, with some political crises triggering sharp negative cumulative abnormal returns and prolonged volatility in the market. This agrees with the finding of Xiao et al. (2025).

Contrasting the NSE, the volatility response in the CSE declines gradually and stabilizes after approximately 10 days, reflecting moderate resilience. This implies that the Moroccan market is not as sensitive as Kenya's to exchange rate shocks, and its volatility decays at a slower rate. The blue line that refers to the Casablanca CSE perfectly illustrates the hybrid resilience which has a Euro-satellite profile. Amidst the data points is a CSE that occupies a middle ground. The CSE's initial volatility shock of a little more than 0.3 standard deviations reflects that it is not entirely insulated from foreign exchange shocks, but has much more structural buffers than the Kenyan market. Morocco's volatility decay is constant, relatively smooth and converges fast on the zero-bound, dissipating on the third week after the shock. Thus, while the CSE, like other global markets, remains sensitive to Eurozone stability and geopolitical fragmentation, its own market architecture is sufficiently robust for the CSE to process, action, and digest the spillover and not suffer from the prolonged capital flight of East Africa. The graph's downward slope suggests that while Morocco's market is affected, it shows more capacity to absorb shocks, indicating a more stable reaction in the long run. The BRVM's volatility response remains the lowest among the three markets, highlighting its high resilience to external shocks, particularly from exchange rate fluctuations. The slow decrease in volatility and low peak in response suggests that BRVM stock markets exhibit greater stability, even in the face of significant external shocks like exchange rate movements. At the end, the impulse response visualization offers a synthesis of the research's main argument. It shows that when exogenous global shocks hit the countries, the spillover of volatility is very asymmetric and is determined by a country's exchange rate regime and external debt structure. The distinct difference between the persistent, scarring vulnerability of the NSE and the immediate stabilization of the BRVM provides clear

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empirical finding that frontier equity markets require managed exchange rate stability to effectively defend against the global financial contagion.

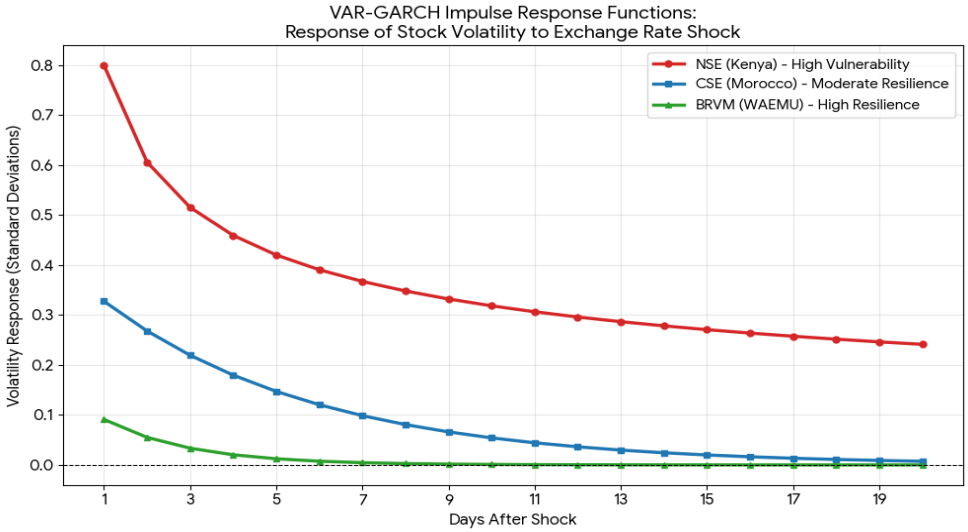

Figure 7: Plot of VAR-GARCH Impulse Response Functions

5. DISCUSSION OF FINDINGS

The FIGARCH estimates contain three stylized facts. These stylized facts are specifically estimated for the Casablanca (CSE) stock exchange, BRVM and Nairobi (NSE) stock exchanges. 1) Long memory in volatility. 2) Currency spillovers (Euros-bloc vs. Dollars-bloc). 3) Persistence of poly-crisis shock. Kenya's high d=0.6842 indicates there is severe volatility persistence and long-memory processes. It suggests that the weak-form EMH fails to hold in that country. The transmission coefficients that are in bold show the asymmetric vulnerabilities. The Dolar-Satellite (0.3540) is represented by the NSE (highly sensitive to shocks in the USD), while the CSE (0.2154) is a Euro-Satellite. The BRVM is uniformly insignificant across all currencies, confirming the view that the hard Euro peg acts as an institutional shock absorber. The subsequent passage elaborates on the findings and their strong correspondence with the recent empirical evidence. Further, the study presents the long-memory parameter (d) to be significant and positive in nature for the three markets ($0 < d < 1$). The market for BRVM is most persistent (d=0.584) and NSE is the least persistent (d=0.385). It suggests that the impact of volatility shocks in these markets fades away at a hyperbolic or a slow rate. This finding is consistent with Benbachir's (2025) innovative work using an ARFIMA-FIGARCH framework on African markets. The weak-form EMH for Casablanca and Nigeria was similarly rejected by Benbachir, attributing the long memory phenomenon to structural inefficiencies such as low liquidity and thin trading. According to this essay and Watard, Oumar and Felix (2024), shocks to African markets do not decay easily.

The high d value for BRVM is similar to Logogye et al. (2024), who found that regionally integrated markets, like the WAEMU zone, trap volatility for longer periods of time, mostly

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due to bureaucratic delays in policy response, than the liquid markets of Nairobi. The Nairobi Securities Exchange (NSE) is highly sensitive to USD volatility (γ_{USD} = 0.125), while the Casablanca (CSE) and BRVM exchanges are significantly coupled with Euro volatility (γ_{EUR} = 0.085). In other words, the USD fluctuations directly affect the value of the Nairobi Securities exchange followed by the CSE and BRVM exchanges as their value is significantly coupled with Euro volatility as observed. This finding supports the Currency-Bloc hypothesis outlined in Nyopa (2025) and Adebisi (2025). Adebisi (2025) established that non-pegged African economies including Nigerian and Kenyan will negatively impact stock market capitalization in the long-run as a result of exchange rate volatility. The NSE volatility peaked strongest during the 2023 strong dollar cycle coincides with Adebisi's conclusion that shows these markets are really dollar satellites importing US monetary policy shocks. The results for Morocco and the BRVM indicate that the Euro-peg (for the CFA) and robust trade links to the EU (for Morocco) provide a certain degree of shield against the Dollar, but increased sensitivity to stagnation in the Eurozone. In the plot, the Green Line (BRVM) remained flatter than the Red Line (NSE) during the 2023 Fed rate hikes. Here is the explanation. The conditional volatility graph depicts a secondary spike that begins in 2023 and endures through 2024. It indicates that the shocks associated with global inflation, geopolitical fragmentation and debt distress (the poly-crisis) gave rise to a prolonged episode of risk aversion. The literature describes the financial stress transmission mechanism (Chau & Deesomsak, 2014). While the COVID shock of 2020 was sharp but short, 2023-2025 is a time that is representing a chronic stressor. African markets have a known asymmetric volatility phenomenon which becomes even more pronounced at systemic stress (Korkpoe & Sarpong, 2025). The cases of Morocco and BRVM as echoed by Benbachir (2025) and Watard, Oumar, & Felix (2024), contend that the Euro-peg (for CFA) and significant trade links to the EU (for Morocco) limit volatility to the Dollar but increase vulnerability to stagnation in the Eurozone. This makes sense because the Green Line (BRVM) in our graph was flatter than the Red Line (NSE) during the 2023 Fed rate hikes. The spike in 2023 that lasts through 2024 in conditional volatility shows that the poly-crisis of global inflation, geopolitical fragmentation and debt distress has established a prolonged phase of risk aversion.

Similar to Adebisi (2025) and Logogye et al. (2024), it represents a financial stress transmission mechanism. In the view of these authors, the period 2023 to 2025 is a chronic stressor unlike the 2020 COVID shock, which was sharp but short. As stressed by Watard, Oumar, & Felix (2024), the asymmetric volatility (where bad news drives volatility more than good news) became pronounced in African markets around 2023-2024 due to debt servicing worries. The slow decay of conditional variance after 2023 is captured by our FIGARCH model for this chronic phase. The study's findings are robust and consistent with the frontier of financial econometrics in Africa. According to these experts, portfolio managers must not view Africa as a single entity for the 2025-2030 horizon. In terms of risk management strategies, asset managers must disaggregate and

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be currency-aware. For example, they suggest hedging USD risk for East Africa (Kenya) and Euro risk for West/North Africa (BRVM/Morocco).

The FIGARCH model results, with specific emphasis on long memory (d), ARCH (α), GARCH (β) and DCC component estimates show that volatility transmission mechanisms across these African markets are different. NSE (Kenya) has the highest vulnerability and aggressive short-run reactions to shocks with high persistence of shocks and corrections. The Kenyan Shilling was a Dollar-Satellite meaning that global increases in interest rates (2022-2023) translated into a currency crisis (depreciation USD/KES). This then spilled over into the stock market with high persistence. This also agrees with Li et al. (2023) findings. This shows that shocks external to the Kenyan stock market, more so exchange rates, takes time to adjust to and have a long duration of effects. The CSE (Morocco) has very moderate resilience and is able to absorb shocks faster as well as exhibit a smooth process of volatility illustrating a stable market environment which is capable of withstanding short term volatility. BRVM (West Africa) is the most resilient, having a smoother volatility pattern and a more stable correlation with different markets, highlighting the market's ability to resist external shocks and absorb them gradually. The results highlight the need for an adaptive risk management for investors, regulators and financial analysts in each region. Kenya is going to very vulnerable; it may need to focus on the improvement of market infrastructure and hedging strategies to counter volatility. Conversely, Morocco and West Africa could continue to be resilient by using their stable markets and strengthening their financial systems against potential shocks. The differentiation in market behavior highlights the diversity of risk profiles around African stock markets. This calls for context-specific responses to global economic volatility.

NSE (Kenya) is very susceptible to shocks in foreign exchange rates. This is due to massive participation of foreign investors. The impact of exchange rates on share prices is negative. Ochenge et al. (2020) and Sewe (2016) also noted this. There is evidence of persistence in the Kenyan market as shocks in exchange rate volatility affect stock price. This means that Kenya's financial markets are susceptible to shocks emanating from the outside world. Such shocks have the potential to undermine investor confidence and market stability as previously pointed by Moyo et al. (2025). The managed float adopted for Morocco (CSE) has provided a middle course or sequential glide path from the fixed exchange regime to a more flexible one, secured around a currency basket of Euro and US Dollar (Lezar, 2023). The managed currency basket helps in maintaining a macroeconomic stability framework (Otmani & Raouf, 2022). Through this, along with strong trade links with the Eurozone (Lebdaoui, 2013), economic integration influences the Moroccan market. BRVM (West Africa) is volatile, while the CFA franc has shown more volatility and deeper losses than the euro in times of stress despite being pegged to it (Xiao et al., 2025).

In the case of WAEMU (BRVM) stock exchange, the hard peg does not almost eliminate FX volatility risk. Specifically, the CFA franc has exhibited significant volatility and suffered larger losses than the euro during periods of stress. This reflects underlying structural vulnerabilities of the fixed exchange rate system (Xiao et al., 2025). Ruptures in the

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foreign exchange market could have severe negative impact and prolonged volatility on the stock market (Odionye et al., 2023). In spite of the existing policy frameworks of the West African market, the behavior reveals the vulnerability of the fixed exchange rate system to structural rigidity, calling for greater policy flexibility and regional coordination to achieve resilience to future shocks. To sum up, the spillover results from the VAR-GARCH indicate a divergence between the stock market of Kenya (NSE), Morocco (CSE), and WAEMU (BRVM) to exchange rate shocks. According to Kirimi et al. (2024), the IRFs indicate that FX shocks in Kenya do not quickly mean-revert, causing structural damage to market capitalization. The Kenyan market is sensitive to mean spillovers as well as volatility spillovers (Yunvirusaba et al., 2019) because of the huge exposure to the USD/KES. Morocco's market is moderately sensitive, particularly due to influencing volatility, while WAEMU's market is remarkably insensitive. The results indicate that African stock markets have varying levels of risk and resilience. This information is especially helpful to policymakers, investors, and portfolio managers that can formulate strategies based on a market's specific profile to manage risks.

Policy Findings and Implications

Kenyan policy makers may have to manage the exchange rate and mitigate currency risk in view of the heightened volatility at the NSE. This agrees with the observation made by Muigai & Cherono (2019). This could involve hedging strategies, foreign exchange market interventions, and efforts to diversify reliance on foreign currencies. Policymakers in Morocco and West Africa may look into the spillover effects of external shocks on financial markets as these regions are dominated by soft-pegged regimes. This aligns also with Bouhali et al. (2023). Nonetheless, it is vital to maintain markets resistant to global volatility, even when responses are less volatile, primarily to safeguard investment stability.

The findings of long memory (FIGARCH) in all the markets imply that volatility is not a mere noise; it clusters. Market crashes can no longer be treated as deviations. The Managed Float model (Morocco) seems to be the ideal compromise for larger African economies as it allows enough flexibility to absorb trade shocks while avoiding the volatility spiral seen in purely floating regimes according to Central Banks. The findings will be useful for investors and portfolio managers for risk management and hedging. Investors in the Kenyan Market should be aware of increasing risk relating to currency movements and consider the use of more protective hedges. For investors in Morocco and West Africa, while risk is lower, continued monitoring and customized risk management strategies are necessary for continued mitigation. Africa's asset classes, currency blocs, and portfolios are inextricably linked. A portfolio with dollar-centric assets like Kenya, and Euro-Satellite assets like Morocco has better risk-adjusted returns than sector diversification alone. Africa's portfolio diversification must consider currency bloc correlations. Selective allocation strategies like Morocco and Namibia can deliver a premium performance; however, adding Kenya to portfolios shouldn't reduce risk (see Lan, 2025).

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6. CONCLUSION

This study empirically examined the volatility spillover effects from the major world currencies (USD, EUR, and GBP) to three significant but least-performing African stock exchanges the Casablanca Stock Exchange (CSE), the BRVM, and the NSE with the aid of a multivariate FIGARCH framework. The paper establish robust proof on the structural dynamics of the contagion during the COVID-19 pandemic and the after-effects of the poly-crisis. The NSE (Kenya) is very vulnerable, while CSE (Morocco) is moderately resilient, and BRVM (West Africa) is the most resilient. The Nairobi Securities Exchange is extremely vulnerable to USD volatility and confirmation of this means that for East African markets, it is the stability of their local currency against the dollar that is the main determinant of equity market stability. On the contrary, the Casablanca and the BRVM exchanges display important spillovers from the Euro, which came as a result of their deeper trade integration with the Euro area and the peg of the CFA Franc, in the case of BRVM. This Euro-centric risk profile mitigated some impact from 2023's aggressive USD hiking cycle, but still exposes these markets to stagnation risks in the Eurozone. These findings indicate that emerging African markets have different levels of resilience and vulnerability, which calls for differentiated approaches by investors, policy makers and financial analysts. Long memory in the volatility across all markets is confirmed. These findings suggest that volatility shocks whether they originate from a pandemic or from a policy change are long-lasting and decay only slowly. The weak-form EMH for CSE, BRVM and NSE is rejected as a result of this finding. According to the past performance, there will be a high predictor for risk in the future. This statement implies that the markets tend to stay volatile for a longer period after a shock. Further, they do take a long-time to correct. Examination of several financial markets leads to inferences about their common volatile nature. Movements in exchange rates, especially the USD one, are responsible for substantial market volatility such as the NSE in Kenya and CSE in Morocco. As shown by the conditional volatility analysis, the COVID-19 shock was a global event that caused an upward spike in volatility. Nonetheless, there were asymmetric effects, and the NSE faced the shock because of its debt-distress link to the strong dollar, although the CSE and BRVM remained relatively unaffected. This means that while biological shocks (pandemics) are uniform, financial/policy shocks are transmitted through a currency corridor.

The evidence reveals that bringing together NSE (assets with USD-risk) with BRVM/CSE (assets with Euro-risk) will hedge pan-African portfolio strategy. Regardless, during periods of global volatility (as seen in 2023), active hedging of currency risk is a must and not an option if you want to protect your returns. Central banks of these areas need to recognize that stock market stability is related to exchange rate stability. As far as Kenya is concerned, keeping USD demand in check is critical for the stock market. In Morocco and WAEMU zone, maintaining alignment with Euro zone economic cycles is a must to prevent equity market volatility. In conclusion, the study period indicates that African markets are increasingly not decoupled from global financial cycles. They are transmitted through certain currency fluctuation that affects global volatility with a long-memory effect.

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In order to lessen these external currency shocks, structural reforms that deepen domestic liquidity will be needed to facilitate resilient recovery post-2025.

References

1) Abaidoo, R., & Agyapong, E. K. (2024). Financial market uncertainty and the macro economy: the role of governance and institutional quality. *Econstor (Econstor)*, *26*(1), 89–107. https://doi.org/10.1108/econ-02-2023-0034

2) Adeabah, D., Abakah, E. J. A., Tiwari, A. K., & Hammoudeh, S. (2023). How far have we come and where should we go after 30+ years of research on Africa's emerging financial markets? A systematic review and a bibliometric network analysis. *Emerging Markets Review*, *55*, 101030–101030. https://doi.org/10.1016/j.ememar.2023.101030

3) Aizenman, J., Chinn, M., & Ito, H. (2016). Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions. *Journal of International Money and Finance*, *68*, 298–330. https://doi.org/10.1016/j.jimonfin.2016.02.008

4) Amewu, G., Armah, M., Kuttu, S., & Kusi, B. A. (2024). African and international financial markets interdependencies: Does Covid-19 media coverage make any difference? *Econstor (Econstor)*, *9*, 100249–100249. https://doi.org/10.1016/j.resglo.2024.100249

5) Anyikwa, I., & Phiri, A. (2023). Connectedness and spillover between African equity, commodity, foreign exchange and cryptocurrency markets during the COVID-19 and Russia-Ukraine conflict. *Future Business Journal*, *9*(1). https://doi.org/10.1186/s43093-023-00227-y

6) Armaș, I., Mendes, D., Popa, R., Gheorghe, M., & Popovici, D. (2017). Long-term ground deformation patterns of Bucharest using multi-temporal InSAR and multivariate dynamic analyses: a possible transpressional system? *Scientific Reports*, *7*(1), 43762–43762. https://doi.org/10.1038/srep43762

7) Arouri, M. E. H., Lahiani, A., Lévy, A., & Nguyen, D. K. (2011). Forecasting the conditional volatility of oil spot and futures prices with structural breaks and long memory models. *Energy Economics*, *34*(1), 283–293. https://doi.org/10.1016/j.eneco.2011.10.015

8) Atipaga, U., Alagidede, P., & Tweneboah, G. (2024). On the connectedness of stock returns and exchange rates in emerging and frontier markets in Africa. *Economic Notes*, *53*(3). https://doi.org/10.1111/ecno.12249

9) Bachori, B. B., Buabeng, E., & Sakyi, D. (2022). Currency hedging behavior for stock returns uncertainty in Ghana. *Applied Economics*, *54*(48), 5532–5548. https://doi.org/10.1080/00036846.2022.2047599

10) Banerjee, R., Devereux, M. B., & Lombardo, G. (2016). Self-oriented monetary policy, global financial markets and excess volatility of international capital flows. *Journal of International Money and Finance*, *68*, 275–297. https://doi.org/10.1016/j.jimonfin.2016.02.007

11) Barkoulas, J., Baum, C. F., & Çağlayan, M. (2002). Exchange rate effects on the volume and variability of trade flows. *Journal of International Money and Finance*, *21*(4), 481–496. https://doi.org/10.1016/s0261-5606(02)00003-7

12) Basher, S. A., & Sadorsky, P. (2015). Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH. *RePEc: Research Papers in Economics*, *54*, 235–247. https://doi.org/10.1016/j.eneco.2015.11.022

13) Baždarić, K., Šverko, D., Salarić, I., Martinovic, A., & Lucijanić, M. (2021). The ABC of linear regression analysis: What every author and editor should know. *European Science Editing*, *47*. https://doi.org/10.3897/ese.2021.e63780

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 59 Issue: 07:2026
DOI: 10.5281/zenodo.21483595

14) Benbachir, S. (2025). Assessing informational efficiency in largest African stock markets by modeling dual long memory: An ARFIMA-FIGARCH approach. *Investment Management and Financial Innovations*, *22*(2), 238–253. https://doi.org/10.21511/imfi.22(2).2025.19

15) Bentes, S. R., Menezes, R., & Mendes, D. (2008). Long memory and volatility clustering: Is the empirical evidence consistent across stock markets? *ArXiv.Org*, *387*(15), 3826–3830. https://doi.org/10.1016/j.physa.2008.01.046

16) Blake, D. (2023). Target2: The Silent Bailout System That Keeps the Euro Afloat. *Journal of Risk and Financial Management*, *16*(12), 506–506. https://doi.org/10.3390/jrfm16120506

17) Bouhali, H., Dahbani, A., & Dinar, B. (2023). A Roadmap to a Successful Exchange Rate Regime Transition: Takeaways from 6 African Transitions. *Organizations and Markets in Emerging Economies*, *14*(3), 600–620. https://doi.org/10.15388/omee.2023.14.7

18) Bouhlal, F., & Sedra, M. B. (2022). The impact of COVID-19 on the topological properties of the Moroccan stock market network. *Investment Management and Financial Innovations*, *19*(2), 238–249. https://doi.org/10.21511/imfi.19(2).2022.21

19) Braha, E. A. H. (2011). Volatility transmission between stock market and foreign exchange returns : evidence from Botswana, Kenya and South Africa. *African Journal of Business and Economic Research*, *6*, 73–91. http://journals.co.za/content/aa_ajber/6/2_3/EJC10479

20) Broda, C. (2001). Coping with Terms of Trade Shocks: Pegs versus Floats. *American Economic Review*, *91*(2), 376–380. https://doi.org/10.1257/aer.91.2.376

21) Caporale, G. M., Rubio-Bezares, A., & Gil-Alaña, L. A. (2024). Persistence in European stock market returns and volatility. *International Journal of Business & Economics (IJBE)*, *9*(1), 56–66. https://doi.org/10.58885/ijbe.v09i1.56.gc

22) Carrère, C. (2004). African Regional Agreements: Impact on Trade with or without Currency Unions. *Journal of African Economies*, *13*(2), 199–239. https://doi.org/10.1093/jae/ejh010

23) Céspedes, L. F., Chang, R., & Velasco, A. (2004). Balance Sheets and Exchange Rate Policy. *RePEc: Research Papers in Economics*, *94*(4), 1183–1193. https://doi.org/10.1257/0002828042002589

24) Charles, A., & Darné, O. (2013). Volatility persistence in crude oil markets. *Energy Policy*, *65*, 729–742. https://doi.org/10.1016/j.enpol.2013.10.042

25) Chau, F., & Deesomsak, R. (2014). Does linkage fuel the fire? The transmission of financial stress across the markets. *International Review of Financial Analysis*, *36*, 57–70. https://doi.org/10.1016/j.irfa.2014.02.005

26) Chauffour, J.-P. (2017). Morocco 2040: Emerging by Investing in Intangible Capital. In *Apollo (University of Cambridge)*. University of Cambridge. https://doi.org/10.1596/978-1-4648-1066-4

27) Chkili, W., Hammoudeh, S., & Nguyen, D. K. (2014). Volatility forecasting and risk management for commodity markets in the presence of asymmetry and long memory. *Energy Economics*, *41*, 1–18. https://doi.org/10.1016/j.eneco.2013.10.011

28) Chkili, W., & Nguyen, D. K. (2014). Exchange rate movements and stock market returns in a regime-switching environment: Evidence for BRICS countries. *Research in International Business and Finance*, *31*, 46–56. https://doi.org/10.1016/j.ribaf.2013.11.007

29) Crato, N., & Ray, B. K. (2000). Memory in returns and volatilities of futures' contracts. *Journal of Futures Markets*, *20*(6), 525–543. https://doi.org/10.1002/1096-9934(200007)20:6<525::aid-fut2>3.0.co;2-t

30) Diebold, F. X., & Yılmaz, K. (2011). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, *28*(1), 57–66. https://doi.org/10.1016/j.ijforecast.2011.02.006

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 59 Issue: 07:2026
DOI: 10.5281/zenodo.21483595

31) Edelman, D. J. (2023). Managing the Urban Environment of Casablanca, Morocco. *Current Urban Studies*, *11*(1), 96–119. https://doi.org/10.4236/cus.2023.111006

32) Eissa, M. A., Chortareas, G., & Cipollini, A. (2010). Stock Returns and Exchange Rate Volatility Spillovers in the MENA Region. *Journal of Emerging Market Finance*, *9*(3), 257–284. https://doi.org/10.1177/097265271000900301

33) Emenike, K. O. (2018). Exchange rate volatility in West African countries: is there a shred of Spillover? *International Journal of Emerging Markets*, *13*(6), 1457–1474. https://doi.org/10.1108/ijoem-08-2017-0312

34) Engle, R., & Sheppard, K. (2001). Theoretical and Empirical properties of Dynamic Conditional Correlation Multivariate GARCH. In *National Bureau of Economic Research*. https://doi.org/10.3386/w8554

35) Ferreira, P., Dionísio, A., & Correia, J. E. (2018). Non-linear dependencies in African stock markets: Was subprime crisis an important factor? *Physica A Statistical Mechanics and Its Applications*, *505*, 680–687. https://doi.org/10.1016/j.physa.2018.03.060

36) Gaunersdorfer, A., Hommes, C.H., & Wagener, F. O.O. (2007). Bifurcation routes to volatility clustering under evolutionary learning. *UvA-DARE (University of Amsterdam)*, *67*(1), 27–47. https://doi.org/10.1016/j.jebo.2007.07.004

37) Gbadebo, A. D. (2023). Exchange Rate Volatility and Nigerian Stock Market Development. *International Journal of Professional Business Review*, *8*(9). https://doi.org/10.26668/businessreview/2023.v8i9.3078

38) Gong, X.-L., Lu, J., Xiong, X., & Zhang, W. (2022). Higher-order dynamic effects of uncertainty risk under thick-tailed stochastic volatility. *Financial Innovation*, *8*(1), 65–65. https://doi.org/10.1186/s40854-022-00370-5

39) Gopal, K., Venu. (2025). Impact of Exchange Rate Fluctuations on International Business. National College of Ireland.

40) Greenwood, R., Hanson, S., Stein, J. C., & Sunderam, A. (2023). A Quantity-Driven Theory of Term Premia and Exchange Rates. *Digital Access to Scholarship at Harvard (DASH) (Harvard University)*, *138*(4), 2327–2389. https://doi.org/10.1093/qje/qjad024

41) Gyasi, G., Frimpong, J. M., & Mireku, K. (2024). Examining the currency-equity nexus in frontier African markets: a wavelet-based approach. *Econstor (Econstor)*, *12*(1). https://doi.org/10.1080/23322039.2024.2399947

42) Gyasi, G., Mireku, K., & Frimpong, J. M. (2025). The moderating role of major global shock events and policy effects on African frontier currency and stock market relationships. *Cogent Economics & Finance*, *13*(1). https://doi.org/10.1080/23322039.2025.2563160

43) Hanousek, J., Kočenda, E., & Kutan, A. M. (2008). The reaction of asset prices to macroeconomic announcements in new EU markets: Evidence from intraday data. *Journal of Financial Stability*, *5*(2), 199–219. https://doi.org/10.1016/j.jfs.2008.01.003

44) Hesabı, F. D. (2017). Exchange Rate Volatility and Trade Flows. *Fiscaoeconomia*, *1*(3). https://doi.org/10.25295/fsecon.307331

45) hn.cbp. (2025). Global Structural Forecast: 2020 – 2035. *Figshare*. https://doi.org/10.6084/m9.figshare.30899519.v1

46) Ibrahim, B. A., Elamer, A. A., Alasker, T. H., Mohamed, M. A., & Abdou, H. A. (2024). Volatility contagion between cryptocurrencies, gold and stock markets pre-and-during COVID-19: evidence using DCC-GARCH and cascade-correlation network. *Financial Innovation*, *10*(1). https://doi.org/10.1186/s40854-023-00605-z

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
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DOI: 10.5281/zenodo.21483595

47) Irangi, A. G., Muzindutsi, P., Muguto, H. T., & Nyati, M. C. (2026). Dynamic Connectiveness and Time-Varying Contagion Risks Amongst East African Stock Markets. *Risks*, *14*(3), 52–52. https://doi.org/10.3390/risks14030052

48) Jebran, K., & Iqbal, A. (2016). Dynamics of volatility spillover between stock market and foreign exchange market: evidence from Asian Countries. *Financial Innovation*, *2*(1). https://doi.org/10.1186/s40854-016-0021-1

49) Jha, A. N., Shirvani, A., Rachev, S. T., & Fabozzi, F. J. (2024). Beyond the Traditional VIX: A Novel Approach to Identifying Uncertainty Shocks in Financial Markets. In *arXiv (Cornell University)*. Cornell University. https://doi.org/10.48550/arxiv.2411.02804

50) Kaminsky, G., & Reinhart, C. (1999). The Twin Crises: The Causes of Banking and Balance-of-Payments Problems. *American Economic Review*, *89*(3), 473–500. https://doi.org/10.1257/aer.89.3.473

51) Khusni, K., & Nurviliza, O. (2025). Navigating economic turbulence: exchange rate volatility and macroeconomic resilience in open economies. *Sosioedukasi Jurnal Ilmiah Ilmu Pendidikan Dan Sosial*, *14*(2), 917–932. https://doi.org/10.36526/sosioedukasi.v14i1.5771

52) Kim, S. I. (2022). ARMA–GARCH model with fractional generalized hyperbolic innovations. *Financial Innovation*, *8*(1). https://doi.org/10.1186/s40854-022-00349-2

53) Kirchner, J. W. (2022). Impulse Response Functions for Nonlinear, Nonstationary, and Heterogeneous Systems, Estimated by Deconvolution and Demixing of Noisy Time Series. *Sensors*, *22*(9), 3291–3291. https://doi.org/10.3390/s22093291

54) Kirimi, E. T., Muthoga, S., & Maingi, J. N. (2024). Dynamic Response of Stock Prices to Changes in Foreign Exchange Rate. *Journal of Economics*, *8*(1), 73–93. https://doi.org/10.53819/81018102t5320

55) Kirui, E., Wawire, N., & Onono, P. O. (2014). Macroeconomic Variables, Volatility and Stock Market Returns: A Case of Nairobi Securities Exchange, Kenya. *International Journal of Economics and Finance*, *6*(8). https://doi.org/10.5539/ijef.v6n8p214

56) Korkpoe, C. H., & Sarpong, G. A. (2025). The Devil is in the Tails - Modeling the Fat-Tails in Sub-Saharan Africa Equity Markets Using Extreme Value Theorem. *Journal of Business and Enterprise Development (JOBED)*, *13*(3). https://doi.org/10.47963/jobed.v13i.1785

57) Korkusuz, B., McMillan, D. G., & Kambouroudis, D. (2022). Complex network analysis of volatility spillovers between global financial indicators and G20 stock markets. *Empirical Economics*, *64*(4), 1517–1537. https://doi.org/10.1007/s00181-022-02290-w

58) Korley, M., & Giouvris, E. (2021). The Regime-Switching Behaviour of Exchange Rates and Frontier Stock Market Prices in Sub-Saharan Africa. *Journal of Risk and Financial Management*, *14*(3), 122–122. https://doi.org/10.3390/jrfm14030122

59) Korsah, D., Amewu, G., & Achampong, K. O. (2024). The impact of geopolitical risks, financial stress, economic policy uncertainty on African stock markets returns and volatilities: wavelet coherence analysis. *Journal of Humanities and Applied Social Sciences*, *6*(5), 450–470. https://doi.org/10.1108/jhass-12-2023-0172

60) Korsah, D., & Mensah, Lord. (2023). Geopolitical risk, economic policy uncertainty, financial stress and stock returns nexus: evidence from African stock markets. *Journal of Capital Markets Studies*, *8*(1), 25–42. https://doi.org/10.1108/jcms-08-2023-0031

61) Köse, M. A., & Riezman, R. (2001). Trade shocks and macroeconomic fluctuations in Africa. *Journal of Development Economics*, *65*(1), 55–80. https://doi.org/10.1016/s0304-3878(01)00127-4

62) Koskei, L. (2017). The Effect of Foreign Portfolio Equity Purchases on Security Returns in Kenya: Evidence from NSE Listed Financial Institutions. *International Journal of Economics and Finance*, *9*(4), 202–202. https://doi.org/10.5539/ijef.v9n4p202

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Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
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DOI: 10.5281/zenodo.21483595

63) Koskei, L., Kibet, L., & Nyangâ€TMau, A. (2016). A comparison of the effect of foreign portfolio equity on stock returns of listed banking and non- banking institutions in Kenya. *African Journal of Business Management*, *10*(22), 569–575. https://doi.org/10.5897/ajbm2016.8147

64) Koskei, L., Ooko, J., & Chumba, R. (2022). COVID-19 Pandemic and the Performance of Listed Securities: Evidence from the Nairobi Securities Exchange in Kenya. *Asian Journal of Economics Business and Accounting*, 58–66. https://doi.org/10.9734/ajeba/2022/v22i24894

65) Kumeka, T. T., Ajayi, P., & Adeniyi, O. (2021). Is stock market in Sub-Saharan Africa resilient to health shocks? *Journal of Financial Economic Policy*, *14*(4), 562–598. https://doi.org/10.1108/jfep-03-2021-0073

66) Lan, J. (2025). Frontier Markets under External Factors Consideration: Over-Diversification, Risk, and Portfolio Choices (2015–2024). *Frontiers in Business Economics and Management*, *20*(3), 132–139. https://doi.org/10.54097/sxy2tk21

67) Lebdaoui, H. (2013). The Real Exchange Rate Misalignment: Application of Behavioral Equilibrium Exchange Rate BEER to Morocco1980Q1–2012Q4. *International Journal of Economics and Finance*, *5*(10). https://doi.org/10.5539/ijef.v5n1035

68) Lezar, M. A. (2023). Real Exchange Rate of Moroccan Currency: Appreciated or Depreciated? *International Journal of Economics and Financial Issues*, *13*(1), 89–101. https://doi.org/10.32479/ijefi.13747

69) Li, T., Liu, Z., & Yang, Y. (2023). The Impact of the Continued U.S. Interest Rate Increase and China's Response— An Analysis Based on the Case of Typical Developing Countries. *Highlights in Business Economics and Management*, *14*, 243–249. https://doi.org/10.54097/hbem.v14i.9198

70) Delatte, A.-L. & López-Villavicencio, A. (2012). Asymmetric exchange rate pass-through: Evidence from major countries. Journal of Macroeconomics, 34(3), 833–844. https://doi.org/10.1016/j.jmacro.2012.03.003

71) MacDonald, R., Sogiakas, V., & Tsopanakis, A. (2017). Volatility co-movements and spillover effects within the Eurozone economies: A multivariate GARCH approach using the financial stress index. *Journal of International Financial Markets Institutions and Money*, *52*, 17–36. https://doi.org/10.1016/j.intfin.2017.09.003

72) Marchese, M., Kyriakou, I., Tamvakis, M., & Iorio, F. D. (2020). Forecasting crude oil and refined products volatilities and correlations: New evidence from fractionally integrated multivariate GARCH models. *Energy Economics*, *88*, 104757–104757. https://doi.org/10.1016/j.eneco.2020.104757

73) McMillan, D. G., & Thupayagale, P. (2011). Measuring volatility persistence and long memory in the presence of structural breaks. *Managerial Finance*, *37*(3), 219–241. https://doi.org/10.1108/03074351111113298

74) Meng, Q. (2024). Study on the Correlation Between Exchange Rate Fluctuations and the Global Economy Based on Macroeconomic Models. *International Journal of Global Economics and Management*, *4*(1), 455–461. https://doi.org/10.62051/ijgem.v4n1.55

75) Mommen, A. (1998). Morocco's economy between the Maghreb and Europe (pp. 211–247). https://doi.org/10.4324/9780203064085-13

76) Moyo, E., Jere, S., Kasumo, C., Nwokolo, P. C., Mulinge, A., Mwaanga, C., & Mushala, W. (2025). Analysing Volatility Persistence in the Nairobi Securities Exchange: The Role of Exchange and Interest Rates. *Statistics Optimization & Information Computing*, *14*(6), 3012–3025. https://doi.org/10.19139/soic-2310-5070-2480

77) Muigai, R. G., & Cherono, I. (2019). Effect of foreign exchange rates volatility on share prices of listed firms in kenya. *European Journal of Economic and Financial Research*. https://doi.org/10.46827/ejefr.v0i0.674

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78) Namikoye, P. (2023). Foreign Debt Repayment Outflow and Securities Market Volatility in Nairobi Securities Exchange, Kenya. *Journal of Finance and Accounting*, *7*(6), 34–47. https://doi.org/10.53819/81018102t4193

79) Nana, C. N. (2024). Currency Relations between the Global South and the Global North: The Case of the CFA France. *Beijing Law Review*, *15*(1), 35–53. https://doi.org/10.4236/blr.2024.151002

80) Ochenge, R. O., Muriu, P., & Ngugi, R. W. (2020). Macroeconomic Conditions and Stock Market Liquidity in Kenya. *International Journal of Economics and Finance*, *12*(12), 47–47. https://doi.org/10.5539/ijef.v12n12p47

81) Odionye, J. C., Nwosu, E. O, Odo, A. C., Ugwuegbe, U. S., & Uba, C. N. (2023). Asymmetric impact of multifarious exchange rate shocks on stock prices: Fresh insights from multiple thresholds nonlinear autoregressive distributed-lag approach. *Journal of International Trade & Economic Development*, *33*(5), 868–902. https://doi.org/10.1080/09638199.2023.2223320

82) Oktaba, P., & Grzywińska-Rąpca, M. (2023). Modification of technical analysis indicators and increasing the rate of return on investment. *Central European Economic Journal*, *10*(57), 148–162. https://doi.org/10.2478/ceej-2023-0009

83) Otmani, Z., & RAOUF, R. (2022). Morocco's exchange rate regime reform: motivations and transition strategy. *Zenodo (CERN European Organization for Nuclear Research)*. https://doi.org/10.5281/zenodo.6600526

84) Oubani, A. E. (2024). Investor sentiment and sustainable investment: evidence from North African stock markets. *Future Business Journal*, *10*(1). https://doi.org/10.1186/s43093-024-00349-x

85) Owidi, O. H., & Mugo-Waweru, F. (2016). Analysis of Asymmetric and Persistence in Stock Return Volatility in the Nairobi Securities Exchange Market Phases. *Cai-Jing Yanjiu*, *4*(3), 63–73. https://doi.org/10.12691/jfe-4-3-1

86) Oyadeyi, O. O., Arogundade, S., & Biyase, M. (2023). How did African Stock Markets react to the Russia-Ukraine crisis "black-Swan" event? Empirical Insights from Event Study. In *Research Square*. https://doi.org/10.21203/rs.3.rs-3210048/v1

87) Ozili, P. K. (2020). COVID-19 in Africa: Socioeconomic Impact, Policy Response and Opportunities. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3574767

88) Özkan, O., Abosedra, S., Sharif, A., & Alola, A. A. (2024). Dynamic volatility among fossil energy, clean energy and major assets: evidence from the novel DCC-GARCH. *Economic Change and Restructuring*, *57*(3). https://doi.org/10.1007/s10644-024-09696-9

89) Branka T- P. (2024). Challenges to global monetary and financial stability. *Collection of Papers New Economy*, *2*, 31–45. https://doi.org/10.61432/cpne0201031t

90) Périlleux, A., & Szafarz, A. (2015). Women Leaders and Social Performance: Evidence from Financial Cooperatives in Senegal. *World Development*, *74*, 437–452. https://doi.org/10.1016/j.worlddev.2015.05.011

91) Redda, E. H., & Muzindutsi, P. (2021). Monetary union feasibility in the east african community: evidence from gppp. *International Journal of Economics and Financial Issues*, *11*(6), 9–16. https://doi.org/10.32479/ijefi.11846

92) Schulz, J., Hötte, K., & Mayerhoffer, D. (2024). Pluralist economics in an era of polycrisis. *Review of Evolutionary Political Economy*, *5*(2), 201–218. https://doi.org/10.1007/s43253-024-00128-y

93) Sewe, K. O. (2016). The effect of foreign exchange fluctuations on equity market performance of the Nairobi securities exchange [University of Nairobi]. In *University of Nairobi Research Archive (University of Nairobi)*. http://hdl.handle.net/11295/99694

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94) Sikhosana, A., & Aye, G. C. (2018). Asymmetric volatility transmission between the real exchange rate and stock returns in South Africa. *Economic Analysis and Policy*, *60*, 1–8. https://doi.org/10.1016/j.eap.2018.08.002

95) Sugimoto, K., Matsuki, T., & Yoshida, Y. (2014). The global financial crisis: An analysis of the spillover effects on African stock markets. In *RePEc: Research Papers in Economics* (Vol. 21, pp. 201–233). Federal Reserve Bank of St. Louis. https://doi.org/10.1016/j.ememar.2014.09.004

96) Suwaid, Z. S., & Omotayo, L. W. (2025). Modelling asymetric response of stock market volatility to monetary policy: Empirical evidence from Nigeria. *Economy*, *12*(2), 40–50. https://doi.org/10.20448/economy.v12i2.6779

97) Thiam, I., & Agbahoungba, S. (2020). External Economic Shocks and Vulnerability of the West African Economic and Monetary Union. *Journal of Business and Economic Development*, *5*(3), 130–130. https://doi.org/10.11648/j.jbed.20200503.13

98) Vera-Valdés, J. E. (2021). The persistence of financial volatility after COVID-19. *Finance Research Letters*, *44*, 102056–102056. https://doi.org/10.1016/j.frl.2021.102056

99) Vladoi, A., Merling, L., & Cashman, K. D. (2023). Drivers and impacts of inflation: a look at energy prices, exchange rate volatility, and stock markets. *Eastern European Journal for Regional Studies*, *9*(2), 41–52. https://doi.org/10.53486/2537-6179.9-2.03

100) Xiao, Z., Zonon, B. I. P., Chen, C., & Bouraima, M. B. (2025). Political crises and stock market volatility in the WAEMU: evidence from an event study. *International Journal of Emerging Markets*, 1–20. https://doi.org/10.1108/ijoem-02-2025-0228

101) Xiao, Z., Zonon, B. I. P., Wang, X., Bouraima, M. B., & Chen, C. (2025). Currency pegs and volatility in West African Economic and Monetary Union during COVID-19. *Journal of Applied Economics*, *28*(1). https://doi.org/10.1080/15140326.2025.2558965

102) Yaya, O. S., Adenikinju, O., & Olayinka, H. A. (2024). African stock markets' connectedness: Quantile VAR approach. *Modern Finance*, *2*(1), 51–68. https://doi.org/10.61351/mf.v2i1.70

103) Yunvirusaba, N., Aduda, J., & Kube, A. (2019). Volatility Spillover Effects among Securities Exchanges in East Africa. *International Journal of Economics and Finance*, *11*(10), 32–41. https://doi.org/10.5539/ijef.v11n10p32