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Research article

Conditional macroeconomic and stock market volatility under regime switching: Empirical evidence from Africa

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Abstract: We used the Markov switching regression model to establish a relationship between the conditional stock market returns and macroeconomic volatilities. Monthly data from thirteen (13) African stock markets and macroeconomic variables (exchange rate, inflation, interest rate, money supply, and crude oil price) from 2003 to 2022 were employed. We confirmed the existence of two distinct regimes: An economic expansion or a "tranquil" state with less volatility and an economic decline or a "crisis" state with high volatility. Our findings indicated that macroeconomic variables significantly affect both expansion and crisis periods. However, the estimated coefficients were more significant in a tranquil than in a crisis state. The findings of the study were consistent with macroeconomic theory and pointed out policy implications.

Keywords: stock markets volatility; macroeconomic uncertainty; African countries; Markov switching regression

JEL Codes: C34, E44, G15, G10

1. Introduction

The association between stock markets and the real economy is of prime importance to academia, policymakers, and investors. Financial sector liberalization and technological progress have increased the interdependence between the real economy and the stock market. As such, the stock markets react fluidly to changes in economic fundamentals (Vychytilová et al., 2019; Bentes, 2021; Yaya et al., 2024). Certainly, spillover from the real economy readily affects stock markets. Different authors have documented macroeconomic variables that influence stock market returns. The earliest was Fama (1981), who conducted extensive studies to affirm the evidence of a strong positive relationship between equity returns and real economic activities such as industrial production, capital expenditures, and GNP. Others include Nelson (1976), Fama and Schwert (1977), Chen et al. (1986), and Hamao (1988). These authors have progressively moved from the single factor to a multifactor approach in explaining the volatilities of stock returns. In a study, Schwert (1989) confirmed that changes in real economic activity can explain the volatility of stock market returns. Moreover, Chandra (2004) noted that 30–35% of changes in stock price can be attributed to "economy-wide factors".

Since then, various multifactor approaches in studying the movement of stock prices have continuously been published to back this assertion. Few among them are as follows: Maysami et al. (2004), Rapach et al. (2005), Abugri (2008), Kyereboah-Coleman and Agyire-Tettey (2008), Sohail and Hussain (2009), Frimpong (2009), Chinzara (2011) Hosseini et al. (2011), Owusu-Nantwi and Kuwornu (2011), Boako et al. (2015), and Abbas et al. (2018). These studies, which established links between stock market returns and a number of macroeconomic variables in different economies, used several econometric models, including OLS, Vector Autoregressive Model (VAR), Vector Error Correction Model (VECM), Cointegration, and GARCH. However, these models were selected to examine the linear relationship between the stock market and some macroeconomic variables. Also, the authors' selections of the variables reflect only part of the macroeconomic system due to the limitations of the econometric model they adopt (Mukherjee and Naka, 1995; Liu et al., 2021).

Contrary to these studies, there has been a recent upsurge of nonlinear time series models employed in assessing the link between macroeconomic fundamentals and stock market returns (Bahloul et al., 2017; Gopinathan and Durai, 2019; Sanusi and Kapingura, 2022). This is because economic time series data exhibits occasional dramatic persistence breaks in their behavior due to financial crises, changes in government policies, disasters, wars, and social unrest, among others. The most important thing to economists is the apparent propensity of economic variables to behave differently during recessions when factors of production are underused instead of their expected long-run growth. Similarly, a current feature of financial data is the frequent abrupt changes (Hamilton, 1989; Chauvet & Hamilton, 2006). Our objective of this study is to examine the relationship between conditional macroeconomic volatilities and its impact on stock returns with a non-linear model since markets react differently depending on the magnitude of shocks they are subjected to.

Our paper differs from previous research in several ways. First, researchers are mainly focused on advanced economies and sometimes emerging economies. Our interest is devoted to an updated monthly dataset covering 13 African stock markets (ASMs), namely Botswana, Côte d´Ivoire, Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa, Tunisia, Uganda, and Zambia that have undergone several regime changes as a result of crises. Second, unlike most studies that assessed how changes in macroeconomic variables are related to stock market returns for a whole period, this paper estimates the relationship between the time-varying conditional volatility of macroeconomic variables and the time-varying conditional volatility in the African stock market returns and therefore contributes to the literature on the "second moment". Third, the MS-GARCH model ensured that we capture the multiplicity of crises and events (such as Global Financial crisis in 2008–2009, COVID-19 pandemic, and Russia-Ukraine conflict) that occurred during the sample period. The MS-GARCH model with two distinct states, economic expansion or tranquil state with less volatility and economic decline or crisis state with high volatility, effectively captures the regime-switching behavior in the conditional volatility of African stock market returns. The simple MS-GARCH model used in these studies is known to provide a superior in-sample fit of data and does provide a more robust forecast than the Multivariate Switching and Markov-switching ARCH models (King and Botha, 2015).

In this paper, we examine the regime-switching behavior of ASMs and conditional macroeconomic variables namely exchange rate, inflation, short-term interest rate, and money supply. Residual series (return innovations) are first generated from GARCH models. A Markov Switching (MS) model is then used to establish the link between the conditional macroeconomic volatilities and conditional stock market returns after the inability of OLS to address the variance instability over the study period. We document the existence of two distinct regimes: An economic expansion or a 'tranquil' state with less volatility, and an economic decline or a "crisis" state with high volatility. The probabilities of staying in these two states are similar (state 1 = 0.9095 and state 2 = 0.8960) but they differ in the duration (state 1=42 months and state 2 = 27 months). We found that macroeconomic variables have a significant effect on all the ASMs in both regimes, albeit the coefficient estimates are more significant in the economic expansion state than in the decline state.

The rest of the paper is structured as follows: Section 2 presents a review of both theory and empirical evidence related to macroeconomic variables and stock returns, section 3 outlines the data and empirical models employed, and section 4 presents the results of the study. Finally, section 5 puts forward the conclusion of the paper.

2. Literature review

The capital market in Africa is responding to a reduction in the volatility of African economies. Recessions over the past decades are less frequent and not so severe when they occur. This has motivated the proliferation of the establishment of stock markets in many African countries. The proliferation of stock exchanges in Africa is an indication of a sound framework for attracting foreign direct investment and the overall development of the African economies. Moreover, the boom in ASMs thrived on major financial reforms in the continent in the 1990s. These reforms include the financial sector liberalization (especially the banking sector), conversion of state-owned enterprises into private corporations, improving the investment and business environment in Africa (through policies aimed at achieving macroeconomic stability), development of a robust regulatory framework, and enhancement of basic infrastructure for the development of capital markets among others (de la Torre & Schmukler, 2005; Allen et al., 2011; McMillan & Thupayagale, 2011; Boako & Alagidede, 2016; Yaya et al., 2024). Moreover, improvements in technology have improved transaction costs and overall efficiency of the markets. This has increased the integration and connectedness between ASMs and the world markets (Allen et al., 2011; Atenga and Mougoué, 2021).

Uncertainties in returns from investing in Africa are deemed to be a contributing factor to reduced portfolio investment inflows. However, considering the Global financial crisis in 2008–2009, the COVID-19 pandemic, and the recent Russia-Ukraine conflict are offering investors the opportunities to diversify their investment portfolio across diverse geographic regions, suggests an interest in African markets (King and Botha, 2015; Boako and Alagidede, 2016; Bentes, 2021; Yaya et al., 2024). Such diversification opportunities have resulted in rapid and substantial growth in ASMs because of the increased participation of international portfolio investors, in pursuit of higher returns for their investments. This has favorably contributed to the development and modernization of the ASMs (McMillan and Thupayagale, 2011). Hence, an accurate estimation of stock return volatility in ASMs is needed for effective execution of risk management strategies (King and Botha, 2015).

Stock returns volatility has dominated the finance literature for several decades following the stock market crash in 1987 and has gained prominence, attracting much attention as a result of its prime importance in finance. The complex issue in modeling volatility is relevant today despite several innovations in econometrics and the era of machine learning advancements. The seminal works of Mandelbrot (1963) and Fama (1965) pointed out the inadequacy of simple models, and unlike other economic data that assume a constant variance in their returns, financial data does not. This is because these features have implications for optimal asset allocation decisions and risk management practices of investors. Financial time series possess these *stylized* characteristics, which are: have excess kurtosis of well above 3 (*fat tails*); either stability or volatility are contagious or persistent in subsequent periods (*volatility clustering*); negative correlation between stock prices and changes in stock volatility (*leverage effects*); financial time series do not respond to information immediately but takes time to reflect such new information flowing into the financial market (*long memory*); information accumulates at a slower rate when the market is closed than when the market is in operation (*non-trading days*); and a change in volatility is matched by a change in another volatility in the same direction (*co-movements in volatility*). These volatility characteristics of financial data have been documented to exist in African stock markets by several authors, including Alagidede (2009), King and Botha (2015), Boako and Alagidede (2016), Atenga and Mougoué (2021), Sanusi and Kapingura (2022), Szczygielski and Chipeta (2023), and Yaya et al. (2024).

The nexus between stock returns and macroeconomic variables was first proposed by Ross (1976) in his Arbitrage Pricing Theory (APT) model, which argued that there is a linear relationship between a range of macroeconomic variables and stock market returns. The APT model was an extension of other risk factors, besides the equity market risk premium, introduced in the Capital Asset Pricing Model (CAPM) by Sharpe (1964). Ross (1976) suggested that certain macroeconomic variables are essential in explaining the stock returns of capital markets in the United States of America. However, the APT model failed to identify the specific macroeconomic variables that explain the changes in stock market returns. Roll and Ross (1980) made the first attempt to empirically establish that industrial production, unanticipated changes in inflation, the term structure of interest rates, and risk premiums are the determinants of stock market returns. Also, Fama (1981) established that industrial production, capital expenditures, and GNP are predictors of stock returns.

This was built upon by Chen et al. (1986), who found that prices react sensitively to economic news, especially unanticipated news. The authors documented that economic variables, such as exchange rates, interest rates, inflation, industrial production, and money supply significantly affect stock market returns. Further studies by Hamao (1988) replicated the Chen et al. (1986) study in the multi-factor APT framework. He concluded that Japanese stock returns are significantly influenced by changes in expected inflation, the unexpected changes in the risk premium, and slope of the term structure of interest rates. Since then, several researchers have investigated the influence of macroeconomic variables and stock return. Subsequently, numerous empirical studies have been conducted to examine the relationship between stock market returns and a host of macroeconomic variables.

Paddy (1992) argues that the macroeconomic and fiscal environment is one of the building blocks that determine the success or otherwise of the securities market. A conducive macroeconomic environment promotes business profitability, propelling them to a stage where they can access securities for sustained growth. Thus, the dynamic relationship between stock prices and macroeconomic variables can guide a nation's macroeconomic policies (Maysami et al., 2004). Also, Saeed et al. (2012) argue that decision-makers could determine the behavior of stock prices more precisely by knowing effective factors influencing stock return and, thus, make more proper decisions.

From the preceding, macroeconomic variables were established to be critical in predicting the variability of stock market returns. Hence, investors must monitor key macroeconomic variables to predict stock market returns accurately. Key macroeconomic variables usually mentioned include inflation, exchange rate, interest rate, money supply, industrial production, GDP, balance of payments, unemployment rate, fiscal balance, and foreign exchange reserves. On the whole, there are many studies with inconsistent and inconclusive underpinnings. Generally, the signs of macroeconomic variables established to influence stock market returns are mixed in developed and emerging economies. These may be due to the use of different variables and proxies in modeling. Moreover, some conclusions are country or period-specific. In addition, various econometric models have been adopted to model the dynamic relationship between macroeconomic fundamentals and stock market returns.

2.1. Inflation

It is argued that inflation cannot be limited to a monetary phenomenon, which mirrors the quantity of money per unit of output but also profoundly influences stock market volatility (Suhaibu et al., 2017). The Generalized Fisher Hypothesis (Fisher, 1930) postulated that equity market returns are independent of inflation expectations, albeit stock market returns and inflation are positively related. Hence, equities representing claims against the real assets of a business serve as a hedge against inflation. Investors will sell financial assets in exchange for real assets once expected inflation is pronounced. This means the Fisher effect' postulates that stock prices in nominal terms fully reflect expected inflation, which means a positive relationship between stock return and inflation. A positive relationship between the stock market and inflation has been confirmed by authors like Choudhry (2001), Engsted and Tanggaard (2002), and Maysami et al. (2004), among others. Alagidede (2009) investigated whether the stock market provides a hedge against inflation for these six African countries: South Africa, Nigeria, Egypt, Morocco, Tunisia, and Kenya. The author tested the Fisher hypothesis for these African countries. Kenya was the only country where the Fisherian hypothesis was not rejected.

Bodie (1976) claimed that the stock market is immune to inflation pressures. This is because the stock market serves as a hedge against inflation, which implies that investors are fully compensated for increases in the general price level through corresponding increases in nominal stock market returns. Thus, the real returns remain unchanged, and the real value of the stock market should remain unaltered in the long run. This assertion has been confirmed by authors like Anari and Kolari (2001).

However, another strand of literature contradicts the Fisher hypothesis. From the Gordon (1962) model, equity prices partly depend on the expectation of dividends to be paid in its lifetime. As such, a rise in money supply may cause inflation but stimulate economic expectations, leading to stock price increases. Hence, a negative relationship between inflation and stock prices is postulated. An example is an expansionary monetary policy that will lead to a rise in expected inflation, which increases long-term interest rates. This will cause a decline in stock prices due to the fall in the present value of future dividends (Sargant, 1999; Cogley & Sargant, 2002). Adam and Tweneboa (2008) also posit that high inflation increases the cost of living and thus shifts resources from investments to consumption. The monetary policy authorities may respond by increasing the nominal risk-free rate and, hence, the discount rate in the valuation model. Therefore, this results in lower stock prices caused by an increased inflation rate. Also, Fama and Schwert (1977) demonstrated the ambiguity of the Fisher hypothesis. They presented evidence that stock prices are negatively related to both the expected and the unexpected components of the Consumer Price Index or the inflation rate. Fama (1981) also found a negative relationship between stock returns and inflation. Moreover, Udegbunam and Eriki (2001) and Apergis and Eleftheriou (2002) studies showed that inflation negatively influences stock prices in an economy with high inflationary pressures in Nigeria and Greece, respectively. This same result has been concluded by some studies, such as Boyd et al. (2001), Sharpe (2002), and Ratanapakorn and Sharma (2007).

2.2. Interest rate

Several theories link interest rates and stock market returns. The neoclassical theory of interest rate states that a rise in interest rate results in a higher cost of loans. Thus, an increase in the interest rate causes a decrease in private investment and share prices (Mok, 1993). From the Fisher hypothesis, the nominal interest rates on financial assets are expected to move one-to-one with expected inflation (Fisher, 1930). Also, the Dividend Discount Valuation model indicates that interest rate fluctuation impacts the present value of dividends and, hence, stock prices (Chen et al., 1986). Another possible explanation of the relationship between interest rates and stock prices is that many governments use interest rates as a monetary policy tool to control other macroeconomic fundamentals. Therefore, stock markets do not only respond to monetary policy decisions but provide valuable feedback to the central bank regarding the private sector's expectations of future macroeconomic variables (Bernanke & Gertler, 1999; Bjornland & Leitemo, 2009). All the above theoretical underpinnings suggest a negative relationship between stock market returns and interest rates.

Mukherjee and Naka (1995) believe that short-term and long-term interest rate changes are expected to affect the discount rate in the same direction through their effect on the nominal risk-free rate. Therefore, interest rates are expected to negatively affect market returns through the inflationary or discount factor effect (Abugri, 2008). Such expectation is also consistent with Chandra's (2004) conclusion, which states that a rise in interest rate decreases corporate profitability and leads to an increase in the discount rate applied to equity investors. Both of them have adverse impacts on stock prices and vice versa. Therefore, a rise in interest rates is expected to impact the organization's performance negatively.

If the interest rate falls, investors react by transferring their investment to the stock market, leading to a high demand for shares and increased stock prices. On the other hand, an interest rate increase makes investors channel their current investments to the money markets, thereby starving the stock exchange of the needed new investments. Therefore, trading activities are reduced as there are more shares on sale than what buyers want, leading to a fall in prices. According to Chandra (2004), the interest rate varies with time, default risk, inflation rate, and productivity of capital, among others. Therefore, a change in interest rate encourages substitution between stock market and money market instruments, as well as speculative activities. Other researchers have reported that it is not the interest rate itself that is relevant but the yield and default spread that are more likely to influence equity returns (Chen et al., 1986). They, however, concluded that the effect of nominal interest rates on stock prices is expected to be negative. In agreement, authors like Adam and Tweneboah (2008), Humpe and Macmillian (2009), and Hussain et al. (2013) found that interest rates affect stock prices negatively both directly and indirectly. Few economists found positive effects between interest rates and stock prices. For instance, Elton and Gruber (1988) discovered a positive relationship between stock prices and short-term interest rates. Ratanapakorn and Sharma (2007) also reported a positive relationship between S&P 500 and short-term interest rates in the United States. However, they found a negative relationship between stock prices and long-term interest rates. Other authors who concluded a positive relationship between interest rates and stock market returns are Goswami and Jung (1997) and Narayan and Narayan (2012).

2.3. Economic activity (GDP or industrial production)

Ikoku (2010) traces four theoretical linkages between stock prices and a country's economic activity. First, stock prices account for investors' expectations about future economic performance since stock prices reflect and adjust to firms' expected profitability. Second, an increase in stock prices lowers the investment funds available to firms, whereas funds are shifted to real investment and thus increase economic activity. Third, higher stock prices increase shareholders' assets and, thus, their creditworthiness. This leads to a rise in the borrowing capacity of shareholders and an increase in future economic activity. Fourth, increasing stock prices makes shareholders worthy, increasing their purchasing power. Shareholders tend to spend more, leading to more economic activity (Camilleria et al., 2019). Moreover, the flight-to-quality theory suggests that investors will withdraw their equities from economies experiencing perceived instability or a general decline in economic activity, leading to a fall in stock prices. Hence, economic activity proxied by either GDP or industrial production has a positive relationship with stock market returns.

Empirical literature confirms the direct relationship between stock market returns and a country's aggregate economic activity. For example, Fama (1981) concluded that there is a positive relationship between stock market returns and real economic activity. This was replicated by Chen et al. (1986), who came to the same conclusion. Also, Fama (1990) indicates that about 43% of changes in the annual returns of the NYSE are attributed to real activity. Specifically, he found that aggregate economic output was responsible for approximately half of the total variation of the NYSE stock return. Since then, almost every author, including Chen (1991), Wongbangpo and Sharma (2002), and Humpe and Macmillian (2009), concluded that a positive relationship exists between stock returns and overall economic activity.

2.4. Exchange rate

The exchange rate plays an essential role in the mobility of capital due to the increase in globalization. The cash flows of corporate entities are directly and indirectly affected by fluctuations in foreign exchange rates. Hence, the exchange rate is a significant investor risk (Tursoy et al., 2008). According to the Purchasing Power Parity (PPP) conditions, exchange rate fluctuations are adjusted to reflect relative inflation. Under perfect PPP, the exchange rate is adjusted to reflect the law of the single price. Hence, exchange rate movements should not be different from the inflation rate. However, many authors have reported short-to-medium-term deviations from the PPP theory (Frenkel, 1981; Adler & Lehmann, 1983). Jorion (1990) and Dumas and Solnik (1995) report that these deviations are expected to be borne by investors. This could be daunting to investors interested in the African economies, which are known to experience significant currency risk exposures.

Local currency depreciation influences importers' and exporters' sales, prices, and profits. This may lower corporate earnings, which are a determinant of stock prices according to the Dividend Discount Model. Hence, the theory suggests that increases in exchange rates will lead to a rise in stock prices. Bilson et al. (2001) tested whether local macroeconomic variables (money, goods prices, and real activity) have explanatory power over the stock return of 20 exchange emerging markets from 1985–1997. According to Geske and Roll (1983), the exchange rate has been shown to influence stock prices through the effect of the terms of trade effect. The results show that the exchange rate is the most influential macroeconomic variable. Bahmani-Oskooee and Payesteh (1993) reported a bi-directional causality between stock prices and exchange rates, at least in the short run. This has also been verified by Qiao (1996) for the Tokyo Stock Exchange. Also, in export-oriented economies, local currency appreciation reduces the competitiveness of their exports. This will, in turn, have a negative impact on the domestic stock market. Export-oriented companies become less profitable and unattractive to investors when the local currency frequently appreciates (Muthike and Sakwa, 2012). Other empirical evidence that reached a positive relationship between exchange rate and stock returns includes Mukherjee and Naka (1995), Aggarwal (1981), Bilson et al. (2001), and Maku and Atanda (2010).

Another strand of literature believes that depreciation increases the cost of production in local firms, thus lowering corporate profits and stock market returns. Such studies established a negative relationship between exchange rates and stock returns. For example, Solnik (1987) found a negative relationship between real stock returns and exchange rates after using monthly and quarterly data for eight major Western industrial countries from 1973–1983. Using single and multi-index models, Banny and Enlaw (2000) also revealed the relationship between the exchange rate of the Malaysian Ringgit in terms of the USD and stock prices in Kuala Lumpur Stock Exchange (KLSE). They concluded that there was a negative relationship between the exchange rate and KLSE stock prices.

2.5. Crude oil price

The effect of crude oil prices on stock returns has been a matter of debate among academicians. The transmission channels of crude oil price shocks and their impact on macroeconomic and financial variables continue to be discussed with contrasting conclusions (Kilian, 2014; Serletis & Elder, 2011). Some authors assume the crude oil price is an exogenous variable, so the causes underlying crude oil price shocks are not identified (Chen et al., 1986; Huang et al., 1996). Others believe that the crude oil price is an endogenous variable and that oil price changes are driven by innovations and changes in demand and supply (e.g., Kilian, 2008; Hamilton, 2013; Bastianin & Manera, 2018). In order words, stock price volatility depends on the origin of the crude oil price shock.

A rise in oil prices increases revenues to oil-exporting countries and firms to the detriment of oil-importing countries and firms. An increase in crude oil prices in the oil-importing countries leads to lower real economic activity in all sectors of the economy, causing stock returns to fall. This suggests an inverse relationship between stock returns and crude oil prices. Most African countries are net importers of crude oil, and therefore, these economies will be negatively affected by increases in oil prices. Chen et al. (1986) found that stock prices are significantly affected by oil prices after running a regression of portfolios of 20 US stocks from 1958 to 1984. This has been confirmed by studies like Gjerde and Saettem (1999), Achsani and Strohe (2002), Basher and Sadorsky (2006), and Nandha and Faff (2008). However, this has been contradicted by studies that found no significant impact between crude oil prices and stock market returns. Some of these authors are Gay and Nova (2008), Kuwornu and Owusu-Nantwi (2011), and Saeed, Ozra and Meysam (2012).

2.6. Money supply

Money supply is linked to stock market returns in several ways. First, from the monetary portfolio theory, an increase in money supply alters the equilibrium position of money, as investors will adjust their portfolio holdings, causing changes in asset prices, including equities. The portfolio substitution caused by an increase in money supply shifts holdings of money to financial assets (Rozeff, 1974; Abdullah & Hayworth, 1993; Cheung & Lai, 1999). Second, changes in money supply may increase real economic activities, leading to increased earnings for firms and an overall rise in stock prices (Rogalski & Vinso, 1977; Seyed et al., 2011). Third, from the dividend valuation model, a rise in money supply leads to the adjustment of factors that determine stock prices (the risk-free rate, earnings expectations, and risk premium). This creates an excess money supply and, in turn, increases demand for equities (Keran, 1971; Hamburger & Kochin, 1972; Homa & Jaffee, 1971). Another possible explanation is that an increase in money supply causes excess liquidity, which reduces interest rates and consequently leads to a rise in stock prices (Thorbecke, 1997; Sellin, 2001). All these suggest a direct relationship between stock returns and money supply. Chen (2007) used the money supply (M2) growth rate and change in the federal fund rate to study how monetary policy variables affect stock return. Their results revealed that monetary policy hugely affects Standard & Poor's 500 monthly price returns in bear markets. Maysami and Koh (2000) showed a positive relationship between money supply innovation and stock market returns in Singapore.

In contrast, an increase in money supply causes a rise in unanticipated inflation. This may result in a higher interest rate, causing a stock price fall. Hence, the money supply is negatively related to stock returns (Mukherjee & Naka, 1995; Humpe & Macmillian, 2009; Seyed et al., 2011). In addition, discount rates will rise since money supply is directly linked to inflation. Thus, prices fall because of the increase in discount rates. According to Fama (1981), a rise in real activity increases the demand for money, generating an upward relationship between stock market returns and money supply. Increases in money supply boost inflation and the discount rate, thus reducing stock prices, which in this case has a sizeable magnitude to overcome the economic stimulus effect of money supply increases. Wongbangpo and Sharma (2002) also showed that in the ASEAN-5 countries, high inflation in Indonesia and the Philippines leads to a long-run negative relationship between stock prices and the money supply. This is affirmed by Frimpong (2009), who concluded that increasing the money supply in the economy significantly reduces stock returns in the long run.

3. Data and methodology

3.1. Data

The data for this study come from thirteen (13) African stock markets (ASMs) (Botswana, Côte d´Ivoire, Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Nigeria, South Africa, Tunisia, Uganda, and Zambia). These stock markets were selected based on market size, trade volume, and data availability. These ASMs represents more than 95% by total market capitalization and can be used as a proxy for stock movements in Africa. The stock market indexes were used in all the selected countries except Côte d´Ivoire, where the S&P Dow Jones Broad Market Index (BMI) was used. The macroeconomic variables selected are exchange rate, inflation, interest rate, money supply, and crude oil price. Specifically, the exchange rate is represented by national currency per US Dollar for easy comparison, the Consumer Price Index (CPI) as a proxy for inflation, the 3-month Treasury bill as a proxy for interest rate, M3 or M2+ for money supply, and Brent oil prices as crude oil prices. All the data are in monthly series from January 2003 to December 2022. This duration is a relatively long period for such examination and captures these significant recent global crisis (2008 Global Financial Crisis, the COVID-19 pandemic, and Russia-Ukraine conflict). Stock market data were gleaned from DataStream. Macroeconomic data were also obtained from DataStream, the International Monetary Fund, and national sources. All the variables are transformed into returns computed as the logarithmic difference between two consecutive observations generated as follows:

$$r_t = ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

where r_t is the return of the variable at time t; P_t and P_{t-1} denote the current day and previous day observation of each variable, respectively; and *ln* denotes the natural logarithm.

Table 1 presents the mean daily index returns of the series. As expected, the means of the returns are close to zero. Our sample's highest (lowest) mean in the period is Egypt (Ghana). The high standard deviations are indicating high volatility in market returns and the risky nature of the African exchange. Ghana (Namibia) has the sample's highest (lowest) standard deviation. There is also a positive and negative skewness, which suggests that the data distribution has different tails. This is an indication that returns are both symmetric and asymmetric. Also, the kurtosis is greater than the normal value of 3, which indicates a leptokurtic distribution. This shows that the indices exhibit high peaks in their distribution. The skewness and kurtosis show how the equity returns deviate from the normality assumption. Similarly, returns also reject the null hypothesis of the JB statistics. The ADF test shows possible unit roots in the return series. The low ADF test statistics suggest stationarity at the 1% significance level compared to the critical values.

Table 1. Descriptive statistics of monthly African stock returns.

Index	Mean	STD	Skewness	Kurtosis	JB Test Statistic	ADF	Observations
Botswana	0.0048	0.0300	0.3887	7.7399	229.75***	−9.0848***	239
Côte d´Ivoire	0.0075	0.0629	0.1447	3.8807	8.5574***	−14.821***	239
Egypt	0.0128	0.0904	−0.2457	4.4514	23.382***	−12.926***	239
Ghana	0.0015	0.1193	−9.8580	132.37	170529***	−13.985***	239
Kenya	0.0004	0.0559	−0.6677	5.6144	85.823***	−13.250***	239
Mauritius	0.0064	0.0451	−1.9058	17.742	2308.8***	−12.158***	239
Morocco	0.0060	0.0504	−0.1229	6.7412	139.98***	−13.456***	239
Namibia	0.0097	0.0252	0.8227	7.2935	210.53***	−12.638***	239
Nigeria	0.0057	0.0720	−0.4268	7.1280	176.95***	−13.072***	239
South Africa	0.0089	0.0454	−0.2078	3.7785	7.7560***	−16.041***	239
Tunisia	0.0085	0.0346	−0.2853	5.3614	58.772***	−13.425***	239
Uganda	0.0056	0.0682	−0.8223	6.6004	143.62***	−14.785***	220
Zambia	0.0126	0.0507	0.1466	5.9036	84.814***	−5.6020***	239

Note: (The sample period data is period from January 2003 to December 2022. STD denotes standard deviation. JB represents Jarque-Bera, the chi-square statistic for testing normality. The Jarque-Bera rejects normality at the 0.01 significance level, and ADF is the augmented Dickey-Fuller test for unit root. *** denotes 1% statistical significance level.)

Table 2 shows the correlation matrix among ASM returns. Not surprisingly, there is a low correlation among the indices, signifying a weak association among ASMs. However, there is the existence of a significantly positive weak correlation among ASMs as evidenced by the Pearson correlation coefficients. Egypt and South Africa recorded the highest significant correlation coefficients of 0.51, indicating how the two stock markets are relatively connected. On the other hand, two country pairs, Botswana – Nigeria and South Africa – Zambia recorded the lowest correlation coefficients of 0.12. Namibia is the market that does not have any significant correlation coefficient and mostly shows very low correlations with any ASMs.

Figure 1 presents the cumulative returns of investing in an African stock index from January 2003 to December 2022. For the start of January 2003, a 1000-dollar investment is used and we calculate the cumulative returns of the portfolio each month till December 2022. It could be seen that the cumulative returns of the ASMs over the period are similar, except a few outliers, such as Egypt and Zambia, which have a higher than normal of the rest of the indices. The rest of the ASMs revolve around the 5000-dollar return. Significant drops in profit can be observed in the 2008 and 2020 periods when there was a global crisis. It should be emphasized that this investment experiment is conducted under simplified scenarios and external factors, such as risk and transaction cost are not taken into consideration.

Table 2. Correlation matrix.

	BOS	COT	EGY	GHA	KEN	MAU	MOR	NAM	NIG	SA	TUN	UGA	ZAM
BOS	1												
COT	0.14**	1											
EGY	−0.06	0.34***	1										
GHA	0.23***	0.02	−0.03	1									
KEN	0.08	0.34***	0.36***	0.03	1								
MAU	0.14**	0.31***	0.36***	−0.03	0.45***	1							
MOR	0.02	0.38***	0.34***	−0.04	0.21***	0.41***	1						
NAM	0.06	0.05	−0.03	0.03	−0.00	0.09	0.04	1					
NIG	0.12*	0.26***	0.27***	0.04	0.29***	0.32***	0.39***	−0.04	1				
SA	−0.01	0.39***	0.51***	−0.06	0.41***	0.40***	0.35***	0.06	0.26***	1			
TUN	0.07	0.02	0.13*	0.07	0.20***	0.21***	0.15**	−0.01	−0.02	0.05	1		
UGA	0.02	0.21***	0.26***	0.06	0.68***	0.32***	0.24***	0.00	0.21***	0.35***	0.21***	1	
ZAM	0.26***	0.20***	0.08	0.02	0.18***	0.35***	0.18***	0.08	0.29***	0.12*	−0.01	0.15**	1

Note: (Ordinary Pearson Correlation is used in calculating the correlation coefficients followed by its probability values. *,**,*** denote statistical significance at the 10%, 5%, and 1% levels respectively.)

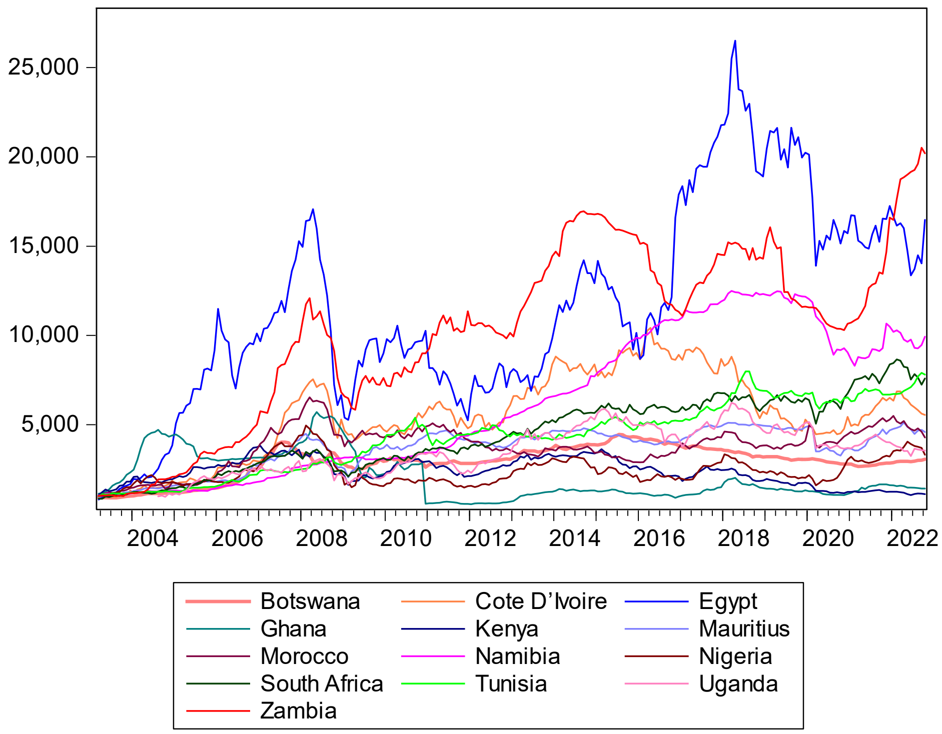

Figure 1. Plot of cumulative returns of ASMs from January 2003 to December 2022.

Table 3 shows the return series of the macroeconomic variables. All macroeconomic variables possessed positive returns except interest rates in some countries in the sample. Specifically, interest rates show a negative return in all countries except Egypt, Ghana, Kenya, and Tunisia. This can be an indication of high interest rates in these countries. Almost all the series exhibited high standard deviation as compared to their mean. The exchange rate fluctuated highest (least) in Zambia and Egypt (Tunisia and Kenya) respectively. For inflation, Kenya followed by Ghana is the most volatile, while Tunisia and South Africa are the least volatile among our sample. Variations in money supply were highest (lowest) in Namibia and Zambia (Morocco and Tunisia). On average, crude oil is the most volatile of all the macroeconomic variables used in the study. The returns also showed symmetric and asymmetric distribution according to the skewness of the series. All returns of the macroeconomic variables unveil a leptokurtic distribution. Similarly, the returns of the macroeconomic variables also reject the null hypothesis of the JB statistics except for the interest rate in Tunisia and the money supply in Uganda. Non-stationarity was observed in inflation (Botswana and Namibia) and money supply (Morocco and South Africa). The rest of the series were all stationary at the level of their returns.

Table 3. Descriptive statistics of macroeconomic variables returns.

Index	Mean	STD	Skewness	Kurtosis	JB Test Statistic	ADF	Observations
Botswana							
Exchange rate	0.0036	0.0319	1.2416	8.5553	368.73***	−16.688***	239
Inflation	0.0053	0.0059	1.5622	7.3323	284.12***	−1.8325	239
Interest rate	−0.0043	0.0722	0.2021	19.223	2359.1***	−13.237***	217
Money supply	0.0076	0.0254	0.2990	4.8230	36.657***	−17.817***	239
Côte d΄Ivoire							
Exchange rate	0.0001	0.0274	0.3211	4.6708	31.905***	−15.745***	239
Inflation	0.0018	0.0073	0.8096	9.6985	472.94***	−13.864***	239
Interest rate	−0.0010	0.0260	1.3902	52.670	24645***	−15.384***	239
Money supply	0.0081	0.0306	−1.7116	15.4771	1667.0***	−4.6778***	239
Egypt							
Exchange rate	0.0064	0.0520	10.083	132.37	170706***	−15.653***	239
Inflation	0.0088	0.0105	0.3473	4.5006	27.227***	−10.299***	239
Interest rate	0.0044	0.0809	1.8792	20.048	3034.8***	−12.978***	239
Money supply	0.0127	0.0131	7.1902	85.824	70371***	−15.103***	239
Ghana							
Exchange rate	0.0097	0.0442	−2.9212	51.921	24172***	−9.6342***	239
Inflation	0.0106	0.0206	−5.8369	77.249	56257***	−12.427***	239
Interest rate	0.0008	0.0586	0.1192	8.7966	335.18***	−7.0451***	239
Money supply	0.0199	0.0310	−0.1552	6.7263	139.23***	−11.720***	239

Continued on next page

Index	Mean	STD	Skewness	Kurtosis	JB Test Statistic	ADF	Observations
Kenya							
Exchange rate	0.0019	0.0202	0.1514	13.296	1056.6***	−11.657***	239
Inflation	0.0035	0.0434	−14.352	216.81	463438***	−15.022***	239
Interest rate	0.0004	0.1517	−0.6757	9.0892	387.42***	−6.7465***	239
Money supply	0.0107	0.0128	1.6781	13.405	1190.3***	−16.100***	239
Mauritius							
Exchange rate	0.0019	0.0233	1.1619	10.052	548.99***	−15.516***	239
Inflation	0.0037	0.0075	0.2220	5.5748	67.980***	−10.743***	239
Interest rate	−0.0040	0.2103	0.2255	17.178	2003.9***	−12.835***	239
Money supply	0.0080	0.0138	3.0231	27.347	6267.2***	−16.515***	239
Morocco							
Exchange rate	0.0002	0.0221	0.4586	5.1425	54.088***	−15.557***	239
Inflation	0.0015	0.0059	0.0604	3.7594	5.8878*	−5.5089***	239
Interest rate	−0.0011	0.0339	0.7730	53.351	25270***	−5.0512***	239
Money supply	0.0062	0.0100	−0.1744	4.2198	16.028***	−1.6594	239
Namibia							
Exchange rate	0.0029	0.0478	0.6174	3.7732	21.138***	−16.576***	239
Inflation	0.0042	0.0051	1.5979	8.8793	445.92***	−2.8835	239
Interest rate	−0.0024	0.0436	−1.9442	11.359	775.52***	−9.4563***	239
Money supply	0.0097	0.0403	7.4426	93.091	83032***	−17.454***	239
Nigeria							
Exchange rate	0.0054	0.0317	7.3906	73.973	52338***	−13.058***	239
Inflation	0.0100	0.0109	0.6099	9.9068	489.88***	−11.591***	239
Interest rate	−0.0051	0.3506	−1.1605	55.294	27286***	−13.375***	239
Money supply	0.0146	0.0354	1.2968	10.018	557.45***	−14.092***	239
South Africa							
Exchange rate	0.0029	0.0477	0.6030	3.8963	22.481***	−16.552***	239
Inflation	0.0042	0.0044	0.3822	3.8093	12.340***	−10.443***	239
Interest rate	−0.0026	0.0369	−1.4541	9.9875	570.44***	−8.5018***	239
Money supply	0.0079	0.0112	0.6407	3.9951	26.214***	−1.7875	239
Tunisia							
Exchange rate	0.0036	0.0207	0.5455	4.9136	48.318***	−14.099***	239
Inflation	0.0040	0.0032	0.0194	2.8044	0.3961	−3.5254***	239
Interest rate	0.0009	0.0308	0.2210	16.825	1905.4***	−14.992***	239
Money supply	0.0076	0.0099	0.4176	3.5372	9.8212***	−14.670***	239

Continued on next page

Index	Mean	STD	Skewness	Kurtosis	JB Test Statistic	ADF	Observations
Uganda							
Exchange rate	0.0029	0.0249	0.4767	7.2404	188.12***	−12.745***	239
Inflation	0.0054	0.0085	1.1552	7.1891	227.91***	−11.815***	239
Interest rate	−0.0011	0.0945	−1.7133	10.450	669.67***	−9.7497***	239
Money supply	0.0120	0.0229	0.2880	3.1505	3.5283	−5.0558***	239
Zambia							
Exchange rate	0.0057	0.0546	0.5206	11.222	684.05***	−14.546***	239
Inflation	0.0089	0.0080	2.2349	12.297	1059.7***	−7.7825***	239
Interest rate	−0.0024	0.1241	−1.4690	12.824	968.27***	−12.766***	221
Money supply	0.0150	0.0358	0.0658	3.9271	8.7327***	−10.142***	239
Crude Oil							
Brent Oil	0.0043	0.1141	−0.6538	13.202	1145.5***	−10.818***	239

Note: (The sample period data is period from January 2003 to December 2022. STD denotes standard deviation. JB represents Jarque-Bera, the chi-square statistic for testing normality. The Jarque-Bera rejects normality at the 0.01 significance level, and ADF is the augmented Dickey-Fuller test for unit root. ***, * denotes 1% and 10% statistical significance level respectively.)

3.2. GARCH model

The first step involves estimating a number of AR (P)-GARCH specifications to identify the best model. This involves estimating both symmetric and asymmetric univariate GARCH models to determine the form of conditional volatility equation that fits the series well. These are the standard symmetric GARCH model (Bollerslev, 1986; Taylor, 1986), the exponential GARCH (EGARCH) by Nelson (1991), and the asymmetric GARCH (GJR-GARCH) model of Glosten et al. (1993). The basic GARCH (1,1) model by Bollerslev (1986) and Taylor (1986) is based on the assumption that conditional variance is influenced by its own lags and previous unexpected increases or decreases in returns at time *t*. This GARCH generalized form enables a more parsimonious representation in many applications. GARCH is predominantly used to capture the volatility clustering effect in the stock market data and in the macroeconomic variables. The GARCH specifications are expressed as:

$$r_t = \mu + \varepsilon_t \qquad (2)$$

$$h_t = \omega + \beta h_{t-1} + \alpha \varepsilon_{t-1}^2 \qquad \text{[GARCH]} \qquad (3)$$

$$ln h_t^2 = \omega + \beta ln h_{t-1}^2 + \alpha \left|\frac{\varepsilon_{t-1}}{h_{t-1}}\right| + \gamma \frac{\varepsilon_{t-1}}{h_{t-1}} \qquad \text{[EGARCH]} \qquad (4)$$

$$h_t = \omega + \beta h_{t-1} + \alpha \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1}^2 \eta_{t-1} \qquad \text{[GJR-GARCH]} \qquad (5)$$

where $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$.

r_t = the return of the index at time *t*

μ = the mean of returns

ε_t = the error term (residuals) such that $\varepsilon_t \approx$ WN (μ, σ^2)
h_t = conditional variance of the index
ω = a constant term
ε_{t-1}^2 = the news about volatility from the previous period (the ARCH term)
h_{t-1}= the conditional variance, the last period forecast variance (the GARCH term) must be non-negative.

The asymmetric effect is captured by γ. The presence of leverage effects can be tested by the hypothesis that $\gamma < 0$, and the impact is asymmetric if $\gamma \neq 0$. Equation 2 represents the mean equation, and Equations 3–5 represents the variance equation. The ε_t is a sequence of *iid* random variables with zero mean and constant variance. If z_t is Gaussian $\varepsilon_t = \sigma_t z_t;\ z_t \sim NID(0,1)$ then the error term is conditionally Gaussian. NID refers to normal and independent distributed functions. The specification allows the variance to depend on the variability of recent observations. The ε_t is a Martingale Difference[1] (MD), therefore its unconditional mean is zero and is serially uncorrelated, which satisfies the conditional normality assumption (Xiao & Aydemir, 2007).

After estimating the parsimonious GARCH models, the best-performing model is selected with the help of several information criteria. These include the Akaike Information Criterion (AIC), Schwarz Information Criteria (SIC), and Log-Likelihood Function (log L).

3.3. Linear regression model

In order to analyze the nexus between the conditional volatility of stock markets and macroeconomic variables, conditional volatilities are generated from the GARCH models. An OLS technique is used to estimate the following linear regression model for the ASMs in the sample:

$$h_t = \mu_t + \beta_1 \delta ER_t + \beta_2 \delta INF_t + \beta_3 \delta IR_t + \beta_4 \delta MS_t + \beta_5 \delta OIL_t + \varepsilon_t \quad (6)$$

where h_t is the return innovations or the second moment of the index, β_i are the estimated coefficients, $\delta \mathrm{ER}_t$ is the conditional exchange rate, $\delta \mathrm{INF}_t$ is the changes in CPI, $\delta \mathrm{IR}_t$ is interest rate volatility, and $\delta \mathrm{OIL}_t$ is the volatility in crude oil price.

Although the OLS techniques are very useful to examine the relationships between variables because of their simplicity, they are unable to capture nonlinear relationships among variables. The equations will be subjected to a stability test to determine the suitability of the OLS technique. Specifically, the Ljung-Box Q statistic test on the squared residuals and the Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) test will be applied as proposed by Brown et al. (1975).

3.4. Regime switching model

It has been established that financial markets react differently to large and small shocks and that large shocks cause a faster rate of mean reversion than more minor shocks. It has been explained that

[1]Martingale difference (MD) is given by $E|\varepsilon_t| < \infty$ and $E(\varepsilon_t|\varepsilon_{t-1}) = 0$. MDs have their means as zero and are uncorrelated over time. This series is white noise if the unconditional variance is constant over time (Xiao & Aydemir, 2007).

the volatility adjustments follow two regimes: There is a faster adjustment and less volatility persistence in a high volatility state; there is a slower adjustment and more persistent volatility in a low volatility state (Poon and Granger, 2003). A Markov chain can, therefore, identify the sudden changes in the parameter. The series of models that captures this idea is called the regime-switching model. Hamilton (1988, 1989) first suggested the Markov switching (MS) model to detect the sudden changes in political and economic events on financial and economic time series properties, similar to the GARCH model, which is strictly stationary and covariance stationary.

MS models make the independent variables to be state-dependent. The estimated coefficient β_i in equation (6) is allowed to change over time depending on a particular transition probability. β_i can assume different values according to the market regime or 'state' at time *t* denoted as s_t. Following Bahloul et al. (2017), the transition probabilities are described by a hidden Markov chain given as:

$$h_t = \mu_t + \beta_{1s_t}\delta ER_t + \beta_{2s_t}\delta CPI_t + \beta_{3s_t}\delta IR_t + \beta_{4s_t}\delta MS_t + \beta_{5s_t}\delta OIL_t + \varepsilon_{ts_t} \quad (7)$$

with $\varepsilon_t \sim N(0, \sigma^2)$, α_t is a Markov chain that is irreducible and aperiodic, and has a finite state space consisting of k states (regimes) $s_1, \ldots, s_k$. The assumption is that ε_t and α_t are independent.

Specifically, s_t is assumed to follow a two-state first-order Markov process with a transition matrix given by

$$P = \begin{bmatrix} P_{11} & P_{21} \\ P_{12} & P_{22} \end{bmatrix} \quad (8)$$

$Q(q_{ij})$ denotes the transition probability matrix for shifts between regimes where:
$q_{ij} = \rho(\varepsilon_t = s_1 | \varepsilon_t = s_1), i, j = 1, \ldots, k$

For an irreducible and aperiodic Markov chain with a definite state space, there is a unique vector stationary probabilities denoted by $\pi = [\pi_1, \ldots, \pi_k]$. The variance is assumed to be constant but can change across regimes. The MS model is estimated using a maximum likelihood procedure.

4. Results and discussion

The major results of this article is presented in three propositions and are followed by discussions:

4.1. GARCH results

This section presents the results of the GARCH models (not reported). The conditional mean model was estimated using the best Autoregressive (AR) model. The AR (P) specification was added to the mean equation to ensure a white noise error term. Next, a combination of information criteria (AIC, SIC, and LL values) is used to select the volatility model that best estimates the conditional variance for the study period. The results show the presence of volatility clustering in the stock return series (exceptions are Côte d´Ivoire and Mauritius) and most of the macroeconomic variables. The macroeconomic variables that do not show volatility persistence are CPI for Côte d´Ivoire and Kenya, interest rate for Côte d´Ivoire, and money supply for Morocco.

Also, the result shows that most of the African stock returns asymmetry coefficient (γ) are negative and non-significant. The leverage effect was confirmed only in Botswana, Mauritius, South

Africa, and Uganda. Most African stock market returns exhibit symmetric and insignificant leverage effects. Concerning macroeconomic variables, leverage effect was observed in the exchange rate (Côte d´Ivoire, Egypt, and Morocco), CPI (Ghana, Nigeria, Tunisia, and Zambia), interest rate (Botswana, Nigeria, and Uganda), and money supply (Egypt, Kenya, Mauritius, Morocco, Namibia, and Uganda). On the other hand, a significant but positive asymmetry coefficient was observed in the exchange rate (Egypt, Ghana, South Africa, and Uganda), CPI (Côte d´Ivoire, and Uganda), interest rate (Côte d´Ivoire, Mauritius, Morocco, Tunisia, and Zambia), money supply (Côte d´Ivoire, Ghana, Nigeria, South Africa, and Zambia), and crude oil. This shows that macroeconomic news and volatilities of stock market returns in Africa are mixed.

4.2. Linear regression analysis

In order to capture the volatilities in the stock market returns and the macroeconomic variables, conditional volatilities were generated from the appropriate GARCH model. An OLS equation was estimated for each country using the innovations from each variable and presented in Table 4.

Results show that the exchange rate is significant in Botswana, Côte d´Ivoire, Kenya, Mauritius, Morocco, Namibia, South Africa, Tunisia, and Uganda, while CPI has a significant effect in Egypt, Kenya, Namibia and South Africa, Tunisia, and Zambia. For all the countries, interest rates were found to be irrelevant in determining the short-run fluctuations in African stock markets except Botswana, Mauritius, Tunisia, and Uganda. It was observed that money supply influences stock volatilities in Botswana, Côte d´Ivoire, Ghana, Kenya, South Africa, and Tunisia. Moreover, crude oil prices significantly affect almost all African countries except Botswana, Ghana, Morocco, Namibia, and Tunisia. In order to understand the robustness of OLS in capturing the innovations of stock market returns and macroeconomic variables and stability in the model, the Ljung-Box Q statistic test on the squared residuals (not reported) and the CUSUMSQ test were performed.

Table 4. Results of OLS.

	M	ER	CPI	IR	MS	OIL	R^2	Log(L)
Botswana	0.0004	0.4122	2.5378	−0.1048	0.7352	0.0007	0.2858	1244.0
	1.76*	2.62***	1.39	−5.06***	3.65***	0.53		
Côte d´Ivoire	0.0022	1.6285	−1.2284	0.6999	0.0652	0.0067	0.2460	1219.5
	5.54***	7.58***	−0.82	1.06	1.93*	2.54**		
Egypt	0.0082	−0.1835	−6.0381	−0.0222	0.0641	0.0449	0.2793	1060.9
	17.66***	−1.57	−1.95*	−1.63	0.38	8.85***		
Ghana	0.0037	−0.0341	−1.1665	−0.0843	2.7813	−0.0008	0.0380	784.87
	3.37***	−0.97	−1.07	−0.85	2.84***	−0.05		
Kenya	0.0051	0.6508	−0.7721	−0.0003	−7.4564	0.0115	0.2763	1168.9
	10.0***	5.54***	−2.82***	−0.09	−5.14***	3.52***		
Mauritius	0.0177	−71.256	−439.45	−0.4536	−84.148	7.7344	0.8033	150.00
	0.56	−7.84***	−0.89	−7.46***	−1.08	30.7***		
Morocco	0.0019	0.3503	2.1621	−0.0134	0.7159	0.0187	0.4180	1341.3
	9.32***	2.07***	0.58	−0.28	0.45	11.3***		
Namibia	0.0005	−0.1096	11.2401	0.0138	−0.0006	0.0008	0.0434	1531.3
	2.15**	−1.96*	1.93*	0.73	−0.57	0.99		
Nigeria	0.0054	−0.1474	0.6080	0.0000	−0.6286	0.0290	0.0943	998.51
	5.64***	−0.24	0.35	−0.41	−1.35	4.37***		
South Africa	−0.0023	0.8717	51.6652	0.1382	8.4553	0.0204	0.5013	1251.4
	−4.70***	5.63***	2.35***	1.31	3.25***	7.85***		
Tunisia	0.0022	0.4993	−49.546	−0.5640	−3.3265	0.0006	0.2436	1482.1
	7.76***	2.50**	−4.95***	−3.97***	−1.92*	0.66		
Uganda	−0.0002	4.5820	−14.043	0.5645	−2.8300	0.1320	0.6224	800.23
	−0.20	10.9***	−1.54	2.03**	−1.01	11.2***		
Zambia	0.0026	−0.0305	−18.246	0.0002	0.2563	0.0003	0.0555	1168.1
	9.94***	−1.48	−3.20***	0.39	1.40	0.14		

Note: (Coefficients and Standard errors are represented respectively. R^2 is the coefficient of determination. Log (L) is the log-likelihood ratio. *,**,*** denote statistical significance at the 10%, 5%, and 1% levels respectively.)

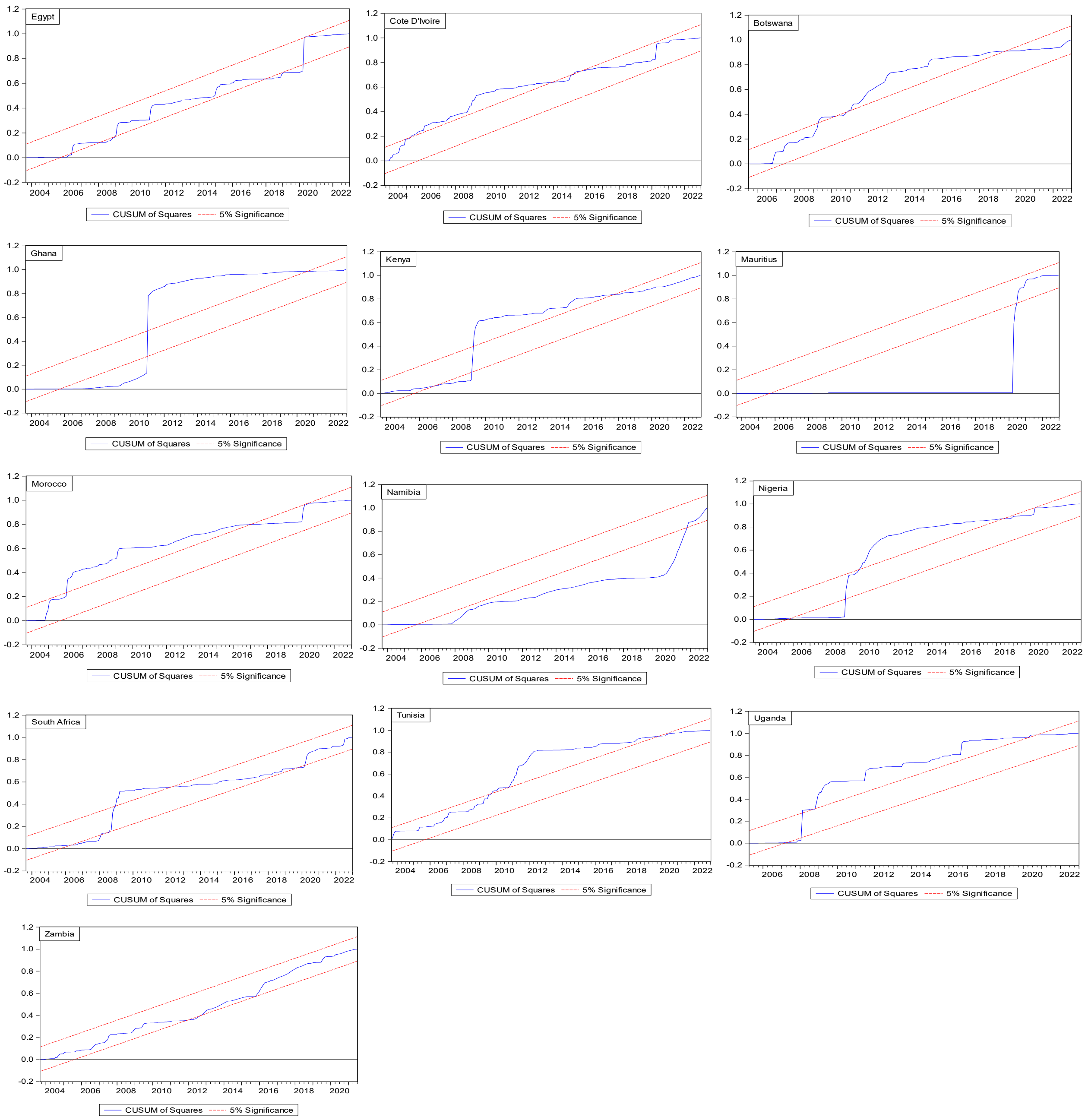

Figure 2. Plot of CUSUMSQ test results.

The results, shown in Figure 2, indicate instability in the coefficients over the sample period since the coefficients are not confined within the 5% critical bounds of parameter stability. This suggests that the OLS is unable to address the variance instability over the study period for African stock markets. It could be argued that African stock indices may have a regime-specific behavior.

4.2. Markov switching regression analysis

This section presents the results of the MS model for the selected countries. The results of MS regression of the conditional stock market volatility and macroeconomic volatilities generated from the GARCH process are presented in Table 5. The results indicate the presence of two distinct regimes: economic expansion or tranquil state and economic decline or crisis state. Regime 1 is characterized as an economic expansion or tranquil state. With less volatility, Regime 2 is an economic decline or crisis state with high volatility. All the conditional means in state 1 are significant except Nigeria. Also, the conditional means in state 2 are significant, except for Côte d´Ivoire, Mauritius, Namibia, and Uganda. Both Regimes 1 and 2 have positive significant conditional mean except South Africa in Regime 1. Regime 1 is less volatile than Regime 2 in ASMs, except in Egypt, Kenya, Nigeria, and South Africa, where the reverse is true.

Table 5. Conditional mean and volatility of the MS model.

	Botswana	Côte d´Ivoire	Egypt	Ghana	Kenya	Mauritius	Morocco	Namibia	Nigeria	South Africa	Tunisia	Uganda	Zambia
Regime 1													
μ_1	0.0003***	0.0028***	0.0138***	0.0026***	0.0099***	0.0012***	0.0018***	0.0004***	0.0061	−0.0043***	0.0009***	0.0026***	0.0016***
cpi	−1.0662***	−0.3498	−13.080**	0.6071***	−1.3196	−0.3734	0.9281	0.5866	−50.914**	9.0438	−3.0888	14.277***	−8.5704***
exr	−0.0645**	0.4872***	−1.7151**	0.002	5.4549**	0.1999***	0.5430***	−0.0713***	−1.67237	0.8264*	0.5164***	0.3752**	−0.0221**
ir	−0.0062**	0.0572	−0.0763	0.0329**	−0.0330**	−0.0005	0.0068	−0.0127	0.00E+00	1.3551***	−0.2519**	0.0103	0.0009***
ms	0.0815***	0.003	6.5603***	−0.0521	−15.485	−0.5052	−0.1279	0.00E+00	15.762**	27.440***	0.4228	−0.812	0.0798
oil	−0.0002	0.0026***	0.0333***	0.0031	0.0857**	0.0045	0.0007	−0.0001	−0.0158	0.0364**	0.0008*	0.0245*	0.0007
σ_1	0.0001***	0.0004***	0.0033***	0.0013***	0.0027***	0.0008***	0.0002***	0.0001***	0.0062***	0.0016***	0.0002***	0.0013***	0.0004***
Regime 2													
μ_2	0.0012***	0.0013	0.0062***	0.0096*	0.0029***	0.1398	0.0059***	0.0016	0.0042***	0.0006*	0.0034***	0.0073	0.0036***
cpi	−9.2499**	24.459	0.1434***	−0.7936	−0.2896***	−2552.6	−48.737**	−9.6743	−0.6007	−21.355	−72.653***	−61.101	−20.066
exr	0.428	1.1858*	−0.0334	0.4194	0.5516***	−141.67***	−0.2667	−0.2250***	−0.15325	0.3927***	0.8962**	6.1772***	−0.0121
ir	−0.2141***	2.9802	−0.0054**	−0.0354	0.0012	−0.0024	−0.1801	0.0162	0.00E+00	0.0722	−0.7476***	−0.5631	−0.0006
ms	1.4231***	0.0166	−0.0026	6.0426*	−1.9869***	−50.716	−3.6728	−0.0027	−0.1801	0.5289	−10.076**	8.8896	0.3138

Continued on next page

	Botswana	Côte d′Ivoire	Egypt	Ghana	Kenya	Mauritius	Morocco	Namibia	Nigeria	South Africa	Tunisia	Uganda	Zambia
oil	0.0073	0.0373**	0.0166***	−0.0745	0.0111***	9.3095***	0.0139***	0.0006	0.0199***	0.0209***	−0.0011	0.1084***	0.0068
σ_2	0.0007***	0.0017***	0.0005***	0.0152***	0.0007***	0.1321***	0.0011***	0.0003***	0.0007***	0.0005***	0.0004***	0.0120***	0.0010***
P_{11}	0.9805***	0.838	0.8280***	0.9945***	0.9263***	0.9037***	0.9688***	0.9896***	0.8305***	0.7328**	0.9214***	0.9388***	0.9712***
P_{22}	0.9563***	0.5705	0.9099***	0.9813***	0.9852***	0.0002	0.8679***	0.9939***	0.9742***	0.9216***	0.8626***	0.6816	0.9580***
$E(d_1)$	51.178	6.1706	5.8148	182.73	13.566	10.386	32.027	165.07	5.898	3.7425	12.719	16.346	34.752
$E(d_2)$	22.904	2.3282	11.099	53.486	67.766	1.0002	7.5673	96.392	38.821	12.761	7.2759	3.1403	23.788
Log (L)	1523.5	1371.9	1262.4	1105.4	1335.9	1195.3	1536.4	1729.4	1279.4	1360	1573.1	1021.4	1304

Note: (P_{11}*and P_{22} are the transition probabilities for shifting between the two regimes; $E(d_1)$ and $E(d_2)$ represent the expected duration in staying in low and high regimes respectively; Log (L) is the log-likelihood ratio; *,**,*** denote statistical significance at the 10%, 5%, and 1% levels respectively.)

The transition probabilities depict the likelihood of remaining in one regime for a specified duration before moving to a second state in a given time. The regime is then switched back to the first state (as only two states are used in this study). A regime is a hidden (latent) state, suggesting that the true state cannot be revealed even with unlimited time series data. The MS model, thus, assists us in revealing the unobservable state of affairs (Giampietroet al., 2018).

P_{11}, the probability of staying in regime 1 (low volatilities) ranges from 0.7328 to 0.9945 with a mean duration of 3.7–182.7 months, which occurs in South Africa and Ghana, respectively. On the other hand, the estimates of P_{22}, the probability of staying in regime 2 (high probability), ranges from 0. 0.5705 to 0.9939 with a mean duration of 2.3–96.4 months in Côte d′Ivoire and Namibia, respectively. The means of state 1 and state 2 are 0.9095 and 0.8960, with a duration of 41.6 and 26.8 months, respectively. Thus, the mean probabilities of staying in state 1 are not different in state 2 but differ in the time of remaining in one state. Also, the high probabilities indicate that both states are persistent, justifying the use of the Markov switching model.

The macroeconomic variables are more significant in the MS model than in the OLS regression. Moreover, the coefficient estimates are more significant in the tranquil state than in the crisis state. It can be inferred that tranquil situations better explain investors' behavior in Africa than in periods of high volatility. Furthermore, all the macroeconomic variables have an impact on the ASMs in all the regimes.

Exchange rate was established to significantly affect conditional stock returns in all the countries in the sample for at least one regime except Ghana and Nigeria. For the rest, the exchange rate is significant in both regimes except Botswana, Egypt, Morocco, and Zambia, which is insignificant in the crisis state only. The sign of the coefficient of exchange rate was positive except for Botswana, Egypt, Namibia, and Zambia in regime 1 and Mauritius and Namibia in regime 2. The expected positive sign recorded indicates that currency fluctuations have a significant impact on ASMs. As noted, the depreciation of local currency will go a long way to decrease corporate profits that form part of equity valuation. Also, the profits of export-oriented firms are significantly reduced when the local currency depreciates. This conclusion was reached by Mukherjee and Naka (1995), Aggarwal (1981), Kyereboah-Coleman and Agyire-Tettey (2008), Frimpong (2009), and Maku and Atanda (2010).

The results of the conditional volatilities of inflation (CPI) in the tranquil regime are mixed. While the Fisherian hypothesis is rejected in Botswana, Egypt, Nigeria, and Zambia, it was not rejected in Ghana and Uganda. Alagidede (2009) also reached a similar conclusion, as Kenya was the only stock market in his sample that did not reject the Fisherian hypothesis. In a crisis state, inflation is negatively related to African stock market returns except in Egypt. Only Côte d´Ivoire, Mauritius, Namibia, and South Africa did not show a relationship between stock market return and inflation in either Regime 1 or Regime 2. Thus, the above inflation and stock market returns results are explained mostly by the Gordon (1962) model and Bodie (1976) assertion. The authors indicate that inflation serves as a hedge against inflation, and therefore, investors are fully compensated for price increases. The negative relationship can also be explained as follows: An increase in inflation decreases the purchasing power of investors who divert their funds to invest in the stock markets, creating market pressures with the consequent price fall. The negative findings are consistent with authors like Udegbunam and Eriki (2001), Boyd, Levine and Smith (2001), Sharpe (2002), Apergis and Eleftheriou (2002), Ratanapakorn and Sharma (2007), and Frimpong (2009).

The conditional volatility of interest rates was more significant for most countries in the tranquil regime than in the crisis state. The direction of the results is also mixed in regime 1. Ghana, South Africa, and Zambia exhibit a positive relationship between interest rate and stock market return, Botswana, Kenya, and Tunisia have a negative relationship during economic expansion. In the crisis state, a negative relationship was established between interest rates and stock market return in ASMs. On the contrary, six of the 13 ASMs (Côte d´Ivoire, Mauritius, Morocco, Namibia, Nigeria, and Uganda) did not establish a significant relationship between interest rate and stock market return in either regime. Results depict that in periods of crisis, an increase in interest rate immediately leads to a fall in stock prices. However, the results are mostly reversed in periods of economic expansion. This is because stocks are substituted for interest-bearing assets, resulting in a decline in stock prices. It should be noted that the positive relationship has been confirmed by a few authors like Elton and Gruber (1988) and Ratanapakorn and Sharma (2007).

For money supply, the impact is significant in Botswana, Egypt, Nigeria, and South Africa in regime 1. In Regime 2, the money supply is statistically significant in Botswana, Ghana, Kenya, and Tunisia. The sign of the coefficient of the money supply is positive, except for Kenya and Tunisia in regime 2. The portfolio theory explains the direct relationship between conditional stock returns and the conditional money supply, as a rise in money supply leads to a portfolio change from noninterest-bearing money to financial assets including equities. Also, a general increase in money supply creates excess liquidity that leads to an increase in real economic activities, leading to increased earnings of firms. Hence, an increase in money supply leads to a rise in stock prices in periods of economic expansion and periods of crisis in African markets. A positive relationship between the two variables has also been confirmed by earlier studies like Abdullah and Hayworth (1993), Thorbecke (1997), Cheung and Lai (1999), Sellin (2001), Seyed Zamri and Yew (2011), and Maysami and Koh (2000), among others.

Finally, it was found that the conditional volatility of Brent oil prices has an impact on stock market volatility, both in periods of low and high volatility. Only four out of the 13 countries, Botswana, Ghana, Namibia, and Zambia, recorded an insignificant relationship with crude oil in both regimes. The sign of the coefficient was positive in all the countries. Even though African countries are net importers of crude oil, a positive relationship was established. It was expected that since crude oil is an essential input for production, increasing crude oil prices would lower real economic activity in all sectors and a subsequent fall in stock returns. However, a positive relationship is confirmed between conditional crude oil volatilities and conditional stock market returns volatilities. These results were also concluded by studies like Gjerde and Saettem (1999), Achsani and Strohe (2002), Basher and Sadorsky (2006), and Nandha and Faff (2008).

5. Conclusions

We considered the nexus between the conditional volatilities of stock market returns and macroeconomic variables for ASMs over the period of January 2003 to December 2022. Conditional volatilities were obtained from stock market returns and macroeconomic variables after estimating GARCH models. A general Markov switching model is then used to assess the link between the conditional stock market and macroeconomic volatilities. The study confirmed the existence of two regimes: An economic expansion or a “tranquil” state with less volatility and an economic decline or a “crisis” state with high volatility. It was observed that ASMs experienced crisis episodes similar to their tranquil periods. It was found that macroeconomic variables have significant effects during both expansion and crisis periods. However, the estimated coefficients are more significant in a tranquil state than in a crisis state, arising interesting prudent investor decisions during periods of economic expansion. Thus, macroeconomic volatilities significantly affect the volatility of stock market returns in Africa.

Our results have several implications. First, the results reveal the weakness in linear models to establish relationship between stock market returns and macroeconomic variables. This suggests that such studies fail to capture abrupt breaks in financial data as a result of financial downturns, political uncertainties and social factors, among others. Hence, it is essential for analysis between stock returns and macroeconomic variables to take into account phases in market regimes as financial data may behave differently during recessions. Second, there are differences in how ASMs react to macroeconomic volatilities. This is driven by domestic factors and how each market reacts to global shocks. It is therefore essential for investors to consider the time-varying effects and dissimilarities in ASMs to maximize their returns. Third, our findings suggest the relationship between ASMs and macroeconomic volatilities is dependent, as such stock market reacts asymmetrically to economic and political events.

Our findings of the study are consistent with macroeconomic theory and point out some policy implications. Portfolio investors and fund managers may be well informed on the dynamic linkage between volatilities in ASMs returns and macroeconomic variables. This ensures that better hedging strategies are adopted during periods of economic expansions and recession. Macroeconomic instabilities were found to influence stock market behavior in Africa. Also, the fragilities of macroeconomic variables result in extended periods of crisis states in African economies. African governments and central banks should therefore put in place sound macroprudential frameworks that are peculiar to each country. Hence, there should be explicit strategies and targets in terms of inflation targeting, reserve requirements, limits on loan concentration and caps on foreign exchange positions, among others.

Even though the study makes valuable contributions on the links between stock returns and macroeconomic variables, it is bedeviled with some limitations. It fails to capture the specific hedging ratios and optimal portfolio weights under the two regimes. They can be derived from the estimated covariance matrix, time, and state variants. Also, we do not examine the specific impact of domestic and global factors on ASMs returns. Again, the nature and persistence of return volatility spillovers across these ASMs are not addressed. Future research can focus on obtaining optimal hedging strategies based on volatility transmission between macroeconomic volatilities and ASMs under regime switching model. Similarly, effect of macroeconomic variability on the volatility spillover between ASMs under regime switching can also be investigated.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflicts of interest in this paper.

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