SPILLOVER EFFECT OF UNITED STATES MONETARY POLICY ON NIGERIA'S STOCK EXCHANGE MARKET

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ABSTRACT

This study analyzed the spillover effects of United States monetary policy on Nigeria's stock exchange market. The period of study accounts for U.S. conventional monetary policy (CMP) from 1985 to 2007 and unconventional monetary policy (UMP), from 2007 to 2020. Considering the volatility of financial time series variables, the study used monthly data and employed BEKK-VARMA-CCC MGARCH model based on relevant pre-tests. Findings reveal that U.S CMP and UMP have spillover effects on the Nigeria's stock market, with, the U.S. exchange rate, having a significant positive spillover effect on the Nigeria's stock exchange market. Further findings reveal that the present volatility in the Nigerian stock exchange market is largely caused by its own past shocks and past, conditional variance of related macroeconomic variables and the volatility due to spillover effects of U.S monetary actions. Thus, the Central Bank of Nigeria should focus on strengthening the exchange rate by pursuing a managed float exchange rate system in order to hedge the spillover effect of U.S. exchange rate on the Nigeria's stock market.

Keywords: *United States' Monetary Policies, Spillover Effects, VARMA-GARCH Model, Nigeria's Stock Exchange Market*
JEL classification: C58, G10

1.0 Introduction

A very important and integral part of a country's financial system is the stock market because it also contributes to the financial development and growth of that country (Raza et al., 2012). In other words, a well-organized and managed stock market encourages investments by identifying and supporting productive projects that can ultimately lead to economic development. The African financial markets experienced a brief expansion in the past. For instance, the number of operating stock exchanges in Africa rose from just 8 in 1989 to 23 in 2007, attaining a total market capitalization of about $2.1 billion (Giovannettia & Velucchi, 2013). Despite this growth, the Nigeria's stock market is the least known of all the financial markets, yet economic analysts use its performance indices to gauge the pace of related economic activities in the country (see, Gunu & Idris, 2009).

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Over the last decades, the outburst of globalization facilitated the integration of World economies more than ever. Regional groupings kept engaging more in cross-border trade and regional integration leading to countries becoming more susceptible to spillover effects from international trade shocks, financial crises and global economic shocks due to spillover effects of foreign policies. For instance, the U.S. housing market policy in 2007, spilt across the World with dire consequences on global trade, investment, and banking operations (Ashamu & Abiola, 2012). Balami (2019) noted that the global output growth in Developed and Emerging Market Economies (EMEs) remained weak due to persistent economic uncertainties and policy spillovers across the globe, occasioned by the trade tension between the US. with its major trading partners. Rey (2013) further argued that the global financial cycle is responsible for the worldwide financial and growth fluctuations, often triggered by U.S monetary policy shocks.

Nigeria is one of the major economic powers in Africa and a leading trading partner with the U.S (Mba, 2013). According to the U.S. Bureau of African Affairs (2021), the United States is the largest foreign investor in Nigeria, with U.S. foreign direct investment concentrated largely in the petroleum/mining and wholesale trade sectors. At $3.2 billion in 2019, Nigeria is the second-largest U.S. export destination in Sub-Saharan Africa, implying that Nigeria is prone to spillover effects from policy adjustments by the U.S. Federal Reserve Bank.

A flurry of studies has shown a co-movement between international monetary policy adjustments and stock markets, since the global collapse of the major stock market boom of 2000 and 2007 (see, Ioannidis & Kontonikas, 2006; Li, Iscan, Xu, 2010; Yoshino, Hesary, Ali, & Ahmad, 214; Benchimol, Saadon, Segev, 2023; Peren, Kaplan, Polyzos, & Spagnolo, 2025). The Nigerian stock market is not immune to international policy adjustments and will likely suffer more from the spillover effects of U.S unconventional monetary policy due to its strong trade relationship with the U.S. This therefore underscores the need to investigate the spillover effect of US. monetary policy on Nigeria's stock market, so as to guide policy design in the financial sector.

2. Literature Review

Before the 2008 GFC crises, the majority of vast literature focused on the effect of cross-border spillover of monetary policy on economic fundamentals while focusing on the conventional approach to conducting monetary policy (see for example, Iacoviello and Navarro 2018; Kose et al, 2017; Ammer et al., 2016; Shuairu and Shigeyuki, 2016; Chenet al., 2015; Hajek and Horvath, 2015; Chen, et al., 2014a; Colombo, 2013; Chinn, 2013; Beaton and Desroches, 2011; Bayoumi and Adrew, 2009). Similarly, a substantial literature mainly focused on the relationship between monetary policy and stock exchange market, laying much emphasis on domestic variables without considering the role of the external (see, Ahmad et. al., 2015; Fadiran & Olowookere, 2016; Ekene, 2016; Ebele & Emmanuel, 2018; Bilesanmi, Ekwueme et al., 2019; Etale & Tabowei, 2019).

The recent 2007/2008 GFC crises, motivated the use of the unconventional monetary policy tools as a key variable in analyzing the degree of the spillover effects of cross-border monetary (see for example, Apostolou and Beirne, 2019; Punzi & Chantapacdepong, 2017; Potjagailo, 2017; Gagnon, Bayoumi, Londono, Saborowski & Sapriza, 2017; Rey, 2016; Chen et al., 2016; Taylor, 2013; Roger et al., 2013 and Neely, 2010), among others. Recently, a flurry of studies, specifically used the VARMA model to investigate the spillover effects of U.S. monetary policy on Nigeria's Financial and Macro Fundamentals. For instance, Tule et al. (2019) examined the effect of the U.S. 10-Year Treasury bond yield between 2011 and 2017 on the Nigerian economy using the vector error correction model. Their findings reveal that domestic factors, such as exchange rate and inflation were key drivers of Nigerian ten (10) years bond yield, rather than the U.S. 10-Year sovereign bond yield. Using the BEKK-VARMA-CCCMGARCH model, Ekeocha and Udeaja (2020) found that the U.S monetary policy had a significant spillover effect on Nigeria's interest rate, exchange rate and inflation rate. Kenneth and Igbanugo (2016) inferred from the Bayesian VARX model that the U.S. UMP exerts a beggar-thy-neighbour effect on the Nigerian economy. That is, the U.S. UMP depresses growth, exports and external reserves in Nigeria. Ekeocha and Udeaja (2020) examined the spillover effects of U.S monetary policy on macroeconomic fundamentals in Nigeria from 1985 to 2018 using the BEKK-VARMA-CCC MGARCH model. They found significant spillover effects of U.S CMP and UMP on interest rate, exchange rate and inflation rate in Nigeria. However, the extent to which the UMP accelerate shocks in inflation varies for different measures of quantitative easing.

Specifically in Nigeria, the vast extant literature that investigated the spillover effect of U.S monetary policies on the Nigeria's financial sector concentrated more on variables like price index, stock returns, number and the number of transactions. None of the researchers investigated specifically the spillover effect of U.S monetary policies on Nigerian stock market capitalization. Furthermore, studies by Julianto and Syafarudin (2019), Iacoviello and Navarro (2019), Kalu et al. (2020) adopted panel data techniques in scrutinizing the spillover effects on multiple countries while Omodero (2020), Takyi and Bentum-Ennin (2020) applied the OLS multiple regression technique for their analysis. However, the major setback with these techniques is that they don't capture the volatility exhibited by most financial time series variables (Ekeocha, and Udeaja, 2020).

Thus, this study filled the gap by focusing on the Nigerian stock market and employed a volatility model (BEKK-VARMA-CCC MGARCH) which is more appropriate in investigating the spillover of U.S. unconventional monetary policy on financial data since it captures the volatility of time series variables.

3. Methodology and Sources of Data

Empirically, the spillover effects of United States monetary policies on the Nigeria's stock exchange market was analyzed using monthly time series data of relevant variables spanning from the period 1985 to 2020. The dependent variables include Market Capitalization (Mcap) also known as market value or market cap and All Share Index (ASI), while the independent variables are Exchange Rate (EXCH) Federal Fund Rate (FFR), and Money Supply (MS) sourced from the Statistical Bulletin of the Central Bank of Nigeria and Federal Reserve Bank of St. Louis, United States.
Table 1 presents the list of those variables, their labels, and proxies. All variables were defined below to reflect both the domestic and foreign variables. Each variable is explained in its capacity and how ot fits into the chosen models for analysis.

Table 1:List of Variable Names and Labels

	Variable Name	Label	Proxy	Adopted from
Stock Market Performance Variable	Market Capitalization	Mcap	Equity Market Capitalization	Izedonmi and Abdullahi (2011)
	All Share Index	ASI	All Share Index	Williams (2011)
Monetary Policy Variables	Federal Fund Rate	FFR	US Federal Fund Rate	US Federal Researve (2021)
	Money Supply	MS	US M2	Gunu and Idris (2009)
	Exchange rate	EXCH	Real Exchange Rate	Tanko (2018).

Source: Authors' own compilation.

The dependent variables are Market Capitalization (Mcap), and All Share Index (ASI), employed as proxies to represent the performance of the Nigerian Stock Exchange Market. These indices of the stock market were used as the dependent variables to explore the effect of U.S. monetary policies on the Nigerian stock market. Market capitalization is the share price times the number of shares outstanding (including their several classes) for listed domestic companies. Investment funds, unit trusts, and companies whose only business goal is to hold shares of other listed companies are excluded (World Bank, 2021). On the other hand, All Share Index (ASI) are a series of numbers generated in the stock market which shows the changing average value of the share prices of all or some companies on a stock exchange, and which is used as a measure of how well a market is performing (Cambridge, 2021).

The effect of foreign monetary variables on other countries' stock markets has been established by a plethora of studies see, Abiola (2012), Giovannettia and Velucchi (2013), Georgiadis (2015), Kenneth and Igbanugo (2016), Iacoviello and Navarro (2019), Tule et al. (2019), Kalu et al. (2020) and Ekeocha and Udeaja (2020). Hence, for this paper, we considered some of these important monetary variables including Federal Fund Rate (FFR), Exchange Rate (EXCH), and Money Supply (MS) as the independent variables.

Model Specification

Volatility-based models are more appropriate for investigating the probable spillover in financial data. This is due to the presence of volatility inherent in most financial series and the inability of the VAR model to capture volatility (Ekeocha, & Udeaja, 2020). More so, the choice of multivariate as against the univariate ARCH or GARCH model is due to the failure of the latter to capture the causality between the conditional variances of the variables of interest (Salisu & Oloko, 2015). The basis of Multivariate GARCH (MGARCH) has been the Vector Conditional Heteroscedasticity (VECH) which is often associated with the problems of too many parameters. Alternative MGARCH models have been developed to allow for some restrictions, as well as, the possibility of volatility transmission (Ekeocha, & Udeaja, 2020). Among the prominent MGARCH models are; the BEKK–GARCH model by Engle and Kroner (1995), the Constant Conditional Correlations (CCC)–GARCH developed by Bollerslev (1990), and the Dynamic Conditional Correlations (DCC)–GARCH model by Engle (2002).

These MGARCH models were revised by McAleer (2003) who developed a VAR-GARCH model with less computational procedure. This was further modified to account for moving average (MA) terms thus, begetting what is now known as the VARMA-GARCH model. Both the VAR-GARCH and VARMA-GARCH enable us to capture volatility spillovers in their respective variance equation (Ekeocha, & Udeaja, 2020). The VARMA-GARCH model is superior in investigating the shocks and volatility spillover effects of U.S monetary policy on the Nigerian stock exchange market and also in analyzing the conditional variance of related macroeconomic variables. The information criteria namely, Schwarz's Bayesian Information Criterion (SBIC) and Akaike information criterion (AIC) are used to rank the different orders of the variants of the VARMA-GARCH.

Following the work of (Salisu and Isah, 2016), below is a representation of a multivariate VARMA(1,1)-MGARCH(1,1) model:

The Conditional Mean Equation [VARMA (1,1)]

$$\mathrm{Y_t} = \mu + \Phi_1 \mathrm{Y_{t-i}} + \Psi_1 UMP_{t-i} + \mathrm{B}\varepsilon_{t-i} + \varepsilon_t \tag{1}$$

where $\mathrm{Y_t}$ = $(y_{1t}, y_{2t})'$ denotes the series for market capitalization (with subscript 1) and all share index (with subscript 2) respectively; $\mu = (\mu_1, \mu_2)'$ is a vector of constants for market capitalization and the all share index respectively; $\Phi = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix}$ is a (2x2) matrix of coefficients of the lagged terms of market capitalization series and it captures spillovers of its past periods; $\Psi = \begin{pmatrix} \Psi_{11} & \Psi_{12} & \Psi_{13} \\ \Psi_{21} & \Psi_{22} & \Psi_{23} \\ \Psi_{31} & \Psi_{32} & \Psi_{33} \end{pmatrix}$ is a (3x3) matrix of coefficients of US monetary policies i.e. federal fund rate, exchange rate and money supply; $\mathrm{B} = \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}$ is a (2x2) matrix of coefficients on the lagged terms of the residuals and $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is a vector of disturbance terms for mean equations of market capitalization and all share index. The spillovers are better appreciated using the individual mean equations below:

$$y_{1t} = \mu_1 + \phi_{11} y_{1t-1} + \phi_{12} y_{1t-2} + \Psi_{11} F_t + \Psi_{12} E_t + \Psi_{13} M_t + \beta_1 \varepsilon_{1t-1} + \beta_2 \varepsilon_{1t-2} + \varepsilon_t \tag{2}$$

$$y_{2t} = \mu_2 + \phi_{21} y_{2t-1} + \phi_{12} y_{2t-2} + \Psi_{21} F_t + \Psi_{22} E_t + \Psi_{23} M_t + \beta_1 \varepsilon_{2t-1} + \beta_2 \varepsilon_{2t-2} + \varepsilon_t \tag{3}$$

Equations (2) and (3) are the respective mean equations for market capitalization y_{1t} and y_{2t} all share index. F, E and M represent Federal Fund Rate (FFR), Exchange Rate (EXCH) and Money Supply (MS) respectively. The return spillover from US monetary policy to market capitalization is measured by $\Psi_{11,} \Psi_{12}$ *and* Ψ_{13} as in equation 2, while the parameters $\Psi_{21,} \Psi_{22}$ *and* Ψ_{23} measures the cross-border spillover of US monetary policy to all share index in the Nigerian stock market as seen in equation (3).

The Conditional Variance Equation [GARCH (1,1)]:

$$\mathrm{H_t} = \mathrm{W} + A\varepsilon_{t-1}^2 + BH_{t-1} \tag{4}$$

Where $\mathrm{H_t} = (h_1, h_2)'$, $\varepsilon_t^2 = (\varepsilon_{1t}^2, \varepsilon_{2t}^2,)'$, *and* W, A, and B is (2x2) matrices of constants, ARCH effects and GARCH effects respectively. Equation (4) can be further simplified into individual conditional variance equations for the two-return series as described below (Arouri, Lahiani and Nguyen, 2011):

$$h_{1t} = c_1 + \alpha_{11}\varepsilon_{1t-1}^2 + \alpha_{12}\varepsilon_{1t-2}^2 + \beta_{11} h_{1t-1} + \beta_{12} h_{1t-2} \tag{5}$$

$$h_{2t} = c_2 + \alpha_{21}\varepsilon_{1t-1}^2 + \alpha_{22}\varepsilon_{2t-2}^2 + \beta_{21} h_{2t-1} + \beta_{22} h_{2t-2} \tag{6}$$

The volatility spillover effects appear more evident in equations (5) and (6). For instance, the conditional variance of market capitalization in equation (5) depends not only on own innovations but also on shocks due to changes in monetary policy in the U.S. The same explanation holds for the conditional variance of all share index in equation (6). Thus, the cross-border spillover of US monetary policies on the Nigerian stock market is easily quantified using the VARMA-GARCH model.

To estimate the probable spillover effect of U.S. monetary policy on the Nigerian stock market, the paper estimated different variants of the VARMA-GARCH model, namely: (i) VARMA(1,1)-GARCH(1,1); (ii) VARMA(1,2)-GARCH (1,1) (iii) VARMA(2,1)-GARCH(1,1), VARMA(2,2)-GARCH(1,1). Each of these variants of MGARCH models is evaluated with options of CCC, DCC and BEKK. The essence is to ensure that all possible inherent features of the investigated series are accounted for in the estimation process.

Pre-estimation Tests for VARMA-GARCH Models

Like other multivariate volatility models, the two prominent post-estimation diagnostic tests for the VARMA-GARCH models are the Ljung-Box test for serial correlation and the McLeod-Li tests for ARCH effects. Both tests are performed on the standardized residuals which is defined as $\hat{\varepsilon}_{i,t} = \hat{\eta}_{i,t}\widehat{H}_t^{-1/2}$. The former test has the null hypothesis of no serial correlation while the latter tests the null of no ARCH effects. For the chosen VARMA-GARCH model to be valid, we are not expected to reject the null hypotheses for the two tests. A rejection of the null hypothesis for the Ljung-Box test may imply the inadequacy of the dynamics captured in the mean equation of the model. Thus, one way of resolving this is to increase the lags of the AR and MA terms in the mean equation and thereafter use the model selection criteria such as the Schwartz Bayesian Criterion (SBC) and Akaike Information Criterion (AIC) to determine the optimal lag length (Said & Dickey, 1984). However, a rejection of the null for the McLeod-Li tests is an indication that the variance equation of the model is not properly specified. In other words, some ARCH effects are still present even after estimation. To resolve this problem, it may be necessary to consider other plausible types of the multivariate GARCH models such as the DCC and BEKK rather than increasing the ARCH and GARCH terms (see, Punzi and Chantapacdepong, 2017; Potjagailo, 2017; Gagnon, Bayoumi, Londono, Saborowski and Sapriza, 2017). In this study, both the ARCH and GARCH terms are considered to confirm the appropriateness of the estimated model in the analysis of the spillover effect of the U.S. monetary policy on the Nigerian stock exchange market.

Unit Root Test

It is essential to consider the properties of data in time series analysis, the purpose being to ensure that the methodology is appropriate and the conclusions are accurate and reliable (Tran and Pham 2020). To achieve this, the two famous unit root test tools namely: Augmented Dicky-Fuller (ADF) and Philip-Perron test of unit root analysis were applied to complement one another in identifying the stationarity status of the data with more confidence. However, many financial time series have complicated dynamic structure that cannot be captured by a simple AR(1) model. Said and Dickey (1984) augment the basic autoregressive unit root test to accommodate general ARMA(p, q) models with unknown orders and their test is referred to as the Augmented DickeyFuller (ADF) test. The ADF test tests the null hypothesis that a time series y_t is I(1) against the alternative that it is I(0), assuming that the dynamics in the data have an ARMA structure. The ADF test is based on estimating the test regression

$$y_t = \beta' D_t + \emptyset y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

Where D_t is a vector of deterministic terms (constant, trend etc). The p lagged difference terms, Δy_{t-j}, are used to approximate the ARMA structure of the errors, and the value of p is set so that the error ε_t is serially uncorrelated. The error term is also assumed to be homoskedastic. The specification of the deterministic terms depends on the assumed behavior of y_t under the alternative hypothesis of trend stationarity as described in the previous section. Under the null hypothesis, y_t is I(1) which implies that $\emptyset = 1$.

Phillips-Perron Unit Root Tests

Phillips and Perron (1988) developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. The test regression for the PP tests is

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \quad (8)$$

Where u_t is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the errors u_t of the test regression by directly modifying the test statistics $t_{\pi=0}$ and $T\hat{\pi}$.

Lag Length Selection

It is important to select the appropriate lag structure that will be adopted for further analysis in the study. To achieve that, we consider a model that contains zero coefficients of the last q lags which is defined as the restricted model and the other one is referred to as the unrestricted model. Denote $|\Sigma r|$ and $|\Sigma u|$ as the determinant of the error variance-covariance matrix of the restricted model and the unrestricted model respectively. Assuming the sample size to be T, the joint null hypothesis that the last q lags have zero coefficients is given by,

$$LR = T[\log|\Sigma r| - \log|\Sigma u|] \quad (9)$$

Test for the Existence of Co-Integration

The test for the existence of co-integration is traditionally followed after optimal lag selection. This study considers the Johansen cointegration test to verify the existence of long-run associations among the variables.

Data Description and Preliminary Analysis

The descriptive statistic on Table 2 is used to examined the characteristics of the variables.

Table 2: Presentation of Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Mcap	432	4209.466	5051.147	4.816497	21056.76
ASI	432	16872.76	15290.07	111.3	65652.38
FFR	432	3.496065	2.797573	0.05	9.85
MS	432	3496.468	1227.193	2206.6	7314.3
EXCH	432	111.8784	99.39739	0.8203	381

Source: Author's computation using Eviews 10.

Table 2 shows that Mcap varies between a minimum of 4.816497 to a maximum of 21056.76 It has a mean value of 4209.466 with a 5051.147 standard deviation. ASI varies from a minimum of 111.3 to a maximum of 65652.38. It has a mean value of 16872.76 with a 15290.07 standard deviation. FFR varies from a minimum of 0.05 to a maximum of 9.85. It has a mean value of 3.496065 with a standard deviation of 2.797573 which implies that the series have been stable over time. MS varies from a minimum value of 2206.6 to a maximum value of 7314.3. It has a mean value of 3496.468 with a standard deviation of 1227.193. EXCH varies from a minimum value of 0.8203 to a maximum value of 381. It has a mean value of 111.8784 with a 99.39739 standard deviation.

Financial data are usually volatile in nature, hence the high values of standard deviations as seen in both market capitalization and all share index. A high standard deviation indicates data are more spread out pointing to the highly volatile nature of the series. However, standard deviation values of federal fund rate, money supply and exchange rate are relatively lower than their respective mean values. A standard deviation close to zero indicates that data points are close to the mean.

Diagnostic Test Results

Diagnostic tests were conducted to evaluate the statistical features of the series to justify the adoption of a volatility model for the analyses of spillover effects. The first step in the post-estimation test in any time series analysis is to test whether the variables are stationary and also determine the order of integration of the variable. To achieve this, the Augmented Dicky-Fuller (ADF) and Philip-Perron unit root tests were conducted,

Table 3: Summary of ADF Unit Root Test (Constant and Trend)

	Level			First Difference			
Variables	**None**	**Constant**	**Trend**	**None**	**Constant**	**Trend**	**Order**
Mcap	1.890894	1.032710	-1.285027	-11.25843***	-11.38846***	-16.92253***	I(1)
ASI	0.024404	-1.079233	-2.470258	-10.76781***	-10.79901***	-10.78700***	I(1)
FFR	-1.787110*	-1.771824	-3.056376	-5.621735***	-5.644366***	-5.630522***	I(1)
MS	4.339310	4.670742	2.272853	-6.346828***	-7.174991***	-8.036463***	I(1)
EXCH	2.651293	1.266316	-1.176980	-10.01309***	-10.36153***	-10.54704***	I(1)

Source: Author's computation using E-Views 10
*, **, *** means rejection of the Null hypothesis at 10%; 5% and 1%.

A summary of the ADF test as shown in Table 3 shows that All Share Index (ASI), Market Capitalization (Mcap), Federal Fund Rate (FFR), Money Supply (MS) and Exchange Rate (EXCH) all became stationary at first difference i.e. I(1). Although the Federal Fund Rate (FFR) is significant at a level without trend or intercept, it was however at a 10% level of confidence only. Hence the study further tests at first difference given that the optimal threshold of at least 5% level of confidence is considered in the study.

Table 4: Summary of Phillips-Perron Unit Root Test (Constant and Trend)

	Level			First Difference			
Variables	**None**	**Constant**	**Trend**	**None**	**Constant**	**Trend**	**Order**
Mcap	1.517475	0.660419	-1.750441	-17.25261***	-17.32442***	-17.36116***	I(1)
ASI	-0.393180	-1.466409	-3.088632	-18.68556***	-18.69217***	-18.68268***	I(1)
FFR	-1.865706*	-1.787275	-2.799285	-12.98406***	-13.03403***	-13.03187***	I(1)
MS	5.722217	5.016491	2.348772	-8.211762***	-8.566317***	-8.676690***	I(1)
EXCH	3.182781	1.595014	-0.921469	-14.86135***	-15.14494***	-15.25571***	I(1)

Source: Author's computation using E-Views 10
*, ** and *** indicates 10%, 5% and 1% level of significance

The summary of the Phillips-Perron unit root test from Table 4 is in synch with previous results. Just like the ADF test, the Phillips-Perron unit root test also showed that all variables included in the study become stationary at first difference i.e. I (1). Also, what is even more interesting is that the Federal Fund Rate (FFR) was also significant at level with no trend or intercept at a 10% level of confidence just as seen in the ADF test. We can therefore conclude on the stationarity of the time series given the consistency of both Augmented Dicky-Fuller (ADF) and Philip-Perron unit root test that all variables included in the study became stationary at first difference at 5% level of significance. This requires a cointegration test to check for the existence of a long-run relationship among the variables. Johansen's methodology was used because of its advantage of allowing for more than one cointegration equation (Ahmad & Saad, 2020). However, preceding the test for the long-run association is the need to identify an appropriate number of lag(s) to adopt for the study which is done via a VAR lag order selection criterion i.e., below:

Therefore, in any econometric analysis, the number of lags to include in a model is very important because of its impact on the result of the analysis. The number of lags suggested by the majority of the different criteria is considered to be the optimal lag length. In other cases, the criterion with the least value is considered better.

Table 5: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-14420.42	NA	4.68e+23	68.69246	68.74056	68.71147
1	-9854.039	9002.288	1.90e+14	47.06685	47.35544	47.18091
2	-9638.780	419.2425	7.67e+13	46.16085	46.68994*	46.36997
3	-9587.261	99.11140	6.77e+13	46.03458	46.80415	46.33875*
4	-9543.628	82.90255	6.19e+13*	45.94585*	46.95591	46.34507

Source; Author's computation using E-Views 10.

* is lag order selection criterion, LR: sequential modified LR test statistic (at 5% level)

The optimal lag length of 4 shall henceforth be adopted for the study as recommended by the Akaike Information Criterion (AIC) above. This is because the AIC has the minimal value and is therefore considered better than both Schwarz and Hannan-Quinn information criteria as shown in Table 5. After the selection of optimal lag, a Co-integration test was conducted using the Johansen Co-integration test based on a maximum lag of 4 as recommended by the AIC lag selection criteria. Employing these variables: Mcap, ASI, FFR, MS and EXCH. The results of the Co-integration test using the Johansen method is presented on Table 6.

Table 6: Summary of Johansen Cointegration Test Result

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.111254	94.93470	69.81889	0.0002
At most 1	0.059579	44.57289	47.85613	0.0985
At most 2	0.022110	18.34340	29.79707	0.5408
At most 3	0.017766	8.796459	15.49471	0.3846
At most 4	0.002671	1.142153	3.841466	0.2852
The Trace test indicates no cointegration at the 0.05 level				
* is rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.111254	50.36181	33.87687	0.0003
At most 1	0.059579	26.22950	27.58434	0.0737

At most 2	0.022110	9.546940	21.13162	0.7860
At most 3	0.017766	7.654306	14.26460	0.4149
At most 4	0.002671	1.142153	3.841466	0.2852

The Max-eigenvalue test indicates no cointegration at the 0.05 level
* is rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source; Author's computation using E-Views 10.

The result of the Johansen Cointegration test suggests no cointegrating equation as indicated by both the Trace statistic and the Max-Eigen statistic. We can therefore conclude that there exists no long-run association among the variables. To check if the series is or not normally distributed, the Jarque-Bera normality test result is presented in Table 7.

Table 7: Summary of Normality Test

Statistics	Market Capitalization	All Share Index
Skewness	1.310146	0.009888
Kurtosis	7.718920	2.349198
Jarque-Bera normality test	524.4144[a]	7.630830[a]

[a] indicates significance at 5% confidence level
Source: Author's computation using E-Views 10.

As shown in Table 7, the null hypothesis of the Jarque-Bera normality test could not be rejected. This suggests that the series does not follow a normal distribution. To test for the presence of Arch effects in the series, Heteroskedasticity was carried out and the result is presented in Table 8.

Table 8: Heteroskedasticity Test (Arch effects)

Market Capitalization			
F-statistic	1596.538	Prob. F (1,429)	0.0000
Obs*R-squared	339.7161	Prob. Chi-Square (1)	0.0000
All Share Index			
F-statistic	5892.819	Prob. F (1,429)	0.0000
Obs*R-squared	401.7522	Prob. Chi-Square (1)	0.0000

Source: Author's computation using E-Views 10.

Table 8 shows that the probability values for Chi-Square in both equations are highly significant at 1%, hence, the null hypothesis of homoscedasticity cannot be accepted indicating the strong presence of ARCH effect which warrants the use of a GARCH model to measure the volatility spillover.

Results of the VARMA-GARCH Models

Summary of results from the volatility model investigating spillover effects are presented below, Table 11 shows the summary of Standard Model Selection Criteria for the first objective of the study while Tables 12 and 13 contain the summary of results from the model. The same is achieved for the second objective in Tables 14 to 15.

Table 9: Standard Model Selection Criteria Market Capitalization (Mcap)

Information Criteria	AIC	SBC	Hannan-Quin	Rank
VARMA(1,1)-CCC-GARCH	11.91661	12.00167	11.95020	2nd
VARMA(1,2)-CCC-GARCH	11.91332	12.00783	11.95064	3rd
VARMA(2,1)-CCC-GARCH	11.67312	11.76763	11.71044	1st
VARMA(2,2)-CCC-GARCH	12.26568	12.36964	12.30673	Not Applicable
VARMA(1,1)-DCC-GARCH	10.15689	10.24195	10.19048	3rd
VARMA(1,2)-DCC-GARCH	10.15013	10.24463	10.18744	2nd
VARMA(2,1)-DCC-GARCH	10.12978	10.22429	10.16710	1st
VARMA(2,2)-DCC-GARCH	10.67613	10.78008	10.71718	Not Applicable
VARMA(1,1)-BEKK-GARCH	10.15689	10.24195	10.19048	1st
VARMA(1,2)- BEKK-GARCH	16.16095	16.25546	16.19827	3rd
VARMA(2,1)- BEKK-GARCH	11.00820	11.10271	11.04552	2nd
VARMA(2,2)- BEKK-GARCH	16.20763	16.31159	16.24868	Not Applicable

Source: Author's computation using E-Views 10

To investigate the influence of spillover effects of United States monetary policies on the market capitalization of the Nigerian stock market, Table 11 presents results obtained from estimating different orders of the VARMA-CCC-GARCH, VARMA-DCC-GARCH and VARMA-BEKK-GARCH models. This is performed in order to find the most robust model by comparing their performances guided by the standard model selection criteria (SIC, AIC and Hannan-Quinn). The results were ranked among different orders of each variant of the VARMA-GARCH model, and thereafter the results with the highest ranks were reported in this study. From

Table 11, the result revealed that the models VARMA (2,1)-CCC-GARCH, VARMA(2,1)-DCC-GARCH and VARMA(1,1)-BEKK-GARCH produce the best fit based on the least values of the standard model selection criteria**.**

Table 10: Summary of the VARMA (2,1)-CCC-GARCH result

Market Capitalization (Mcap)			
Parameters	Mean Equation	Variance Equation	
μ_1	-331.2895 (0.0000) [a]	c_1	-0.119562 (0.2749)
ϕ_{11}	1.058050 (0.0000) [a]	α_{11}	0.767863 (0.0000) [a]
ϕ_{12}	-0.083234 (0.1656)	α_{12}	-0.466122 (0.0000) [a]
ψ_{11}	-1.441986 (0.0000) [a]	β_{11}	0.805202 (0.0000) [a]
ψ_{12}	-0.259321 (0.0000) [a]		
ψ_{13}	0.140132 (0.0000) [a]		
R-squared	0.990423		
Adjusted R-squared	0.990310		

[a] indicates significance at 5% confidence level
Source: Author's computation using E-Views 10

Results from Table 12 suggest that past own shocks affect the volatility of Market Capitalization (Mcap) in the first period. The values of parameters ϕ11 and ϕ12, are used to measure shocks of the lagged values of the dependent variable on itself, and only the first lagged value of Mcap is found significant. Parameters ψ_{12} and ψ_{12} are the coefficients of FFR and EXCH. The values -1.441986 and -0.259321 suggest that a 1% increase in FFR will decrease Mcap in the following month by approximately 1.44% *ceteris paribus*. Also, a 1% increase in EXCH will likely decrease Mcap by 0.26% *ceteris paribus*. The result further suggests that the federal fund rate and exchange rate exert a negative and significant spillover effect on the Nigerian market capitalization. While money supply in the U.S. results in a positive and significant spillover to Mcap in Nigeria. This suggests that monetary policy changes may influence investors' decisions in the Nigerian capital market. The variance equation measures the extent to which the current volatility goes into future volatility. The summation of α_{11} and β_{11} values is ≥ 1 which confirms the existence of volatility in the financial series.

Table 11: Summary of VARMA (2,1)-DCC-GARCH and VARMA(1,1)-BEKK-GARCH results for Market Capitalization (Mcap)

Mean Equation		
Parameters	VARMA(2,1)-DCC-GARCH	VARMA(1,1)-BEKK-GARCH
μ_1	0.082108 (0.9264)	0.070049 (0.9018)
ϕ_{11}	1.201733 (0.0000) [a]	1.195990 (0.0000) [a]
ϕ_{12}	-0.197452 (0.0002) [a]	-0.180780 (0.0013) [a]
ψ_{11}	-0.014196 (0.6937)	-0.020977 (0.2773)
ψ_{12}	0.052817(0.0000) [a]	0.026241 (0.0010) [a]
ψ_{13}	8.98E-06 (0.9757)	2.36E-05 (0.9100)
Variance Equation		
Parameters	VARMA (2,1)-DCC-GARCH	VARMA (1,1)-BEKK-GARCH
c_1	0.001256 (0.2155)	0.000653 (0.7004)
α_{11}	0.753663 (0.0000) [a]	0.818588 (0.0000) [a]
α_{12}	-0.598955 (0.0000) [a]	
β_{11}	0.911139 (0.0000) [a]	0.804077 (0.0000) [a]
	R-squared - 0.990192 Adjusted R-squared - 0.990077	R-squared - 0.990063 Adjusted R-squared - 0.989946

[a] indicates significance at 5% confidence level
Source: Author's computation using E-Views 10

Table 13 shows the results of the VARMA (2,1)-DCC-GARCH and VARMA (1,1)-BEKK-GARCH models rightly chosen from the standard model selection criteria as seen in Table 11. The two models in Table 13 showed a closely similar outcome. The parameters ϕ_{11} and ϕ_{12}, are highly significant in both models, confirming the effect of past volatility of the market capitalization on present volatility. The parameters ψ_{11} and ψ_{13} indicate that the spillover effects that the federal fund rate and money supply have on market capitalization are insignificant in both models. The exchange rate, however, with the parameter ψ_{12} is highly significant. This suggests that a 1% increase in exchange rate will result in a spillover effect in the Nigerian stock market in the following month specifically by increasing the market capitalization by approximately 0.05% or 0.03% *ceteris paribus*, according to the first and second models reported in Table 13. Both models have shown that among the three variables of the United States Monetary Policies, i.e., Federal Fund Rate, Exchange Rate and Money Supply, only Exchange Rate exerts a significant spillover effect on market capitalization. By implication, this means that the spillover effect of US monetary policies affects the Nigerian stock market through the exchange rate channel only.

Table 12: Model Selection Criteria All Share Index (ASI)

Information Criteria	AIC	SBC	Hannan-Quin	Rank
VARMA(1,1)-CCC-GARCH	14.564	14.649	14.598	2^{nd}

VARMA(1,2)-CCC-GARCH	14.567	14.661	14.604	3rd
VARMA(2,1)-CCC-GARCH	14.576	14.67	14.613	Not Applicable
VARMA(2,2)-CCC-GARCH	14.531	14.635	14.572	1st
VARMA(1,1)-DCC-GARCH	14.53661	14.62167	14.57020	2nd
VARMA(1,2)-DCC-GARCH	14.52620	14.62071	14.56352	1st
VARMA(2,1)-DCC-GARCH	14.53591	14.63042	14.57323	3rd
VARMA(2,2)-DCC-GARCH	17.12290	17.22686	17.16395	Not Applicable
VARMA(1,1)-BEKK-GARCH	14.53661	14.62167	14.57020	1st
VARMA(1,2)- BEKK-GARCH	18.04808	18.14258	18.08539	2nd
VARMA(2,1)- BEKK-GARCH	18.09344	18.18794	18.13076	Not Applicable
VARMA(2,2)- BEKK-GARCH	18.08921	18.19317	18.13026	3rd

Source: Author's computation using E-Views 10

Table 14 shows results from different approaches to VARMA-GARCH model estimation i.e., CCC, DCC and BEKK. For robustness, we also estimated models with different orders [VARMA (1,2)-CCC-GARCH, VARMA(2,1)-CCC-GARCH and VARMA(2,2)-CCC-GARCH etc.] and thereafter compare their performance with our model using the standard model selection criteria i.e. SIC, AIC and Hannan-Quinn. This is done in order to find the best (model with the least values in all or at least two of the three standard model selection criteria. The results are ranked among each variation of the CCC, DCC, and BEKK approaches and models with the best fit are ranked 1st. From Table 14, the result revealed that the models VARMA (2,2)-CCC-GARCH, VARMA (1,2)-DCC-GARCH and VARMA (1,1)-BEKK-GARCH produce the best fit based on the lowest values of the standard model selection criteria**.**

Table 13: VARMA (2,2)-CCC-GARCH Result

All Share Index (ASI)			
Parameters	Mean Equation	Variance Equation	
μ_2	21.35330 (0.2359)	C_2	1.423636 (0.2652)
ϕ_{21}	1.191255 (0.0000)[a]	α_{21}	0.775444 (0.0000)[a]
ϕ_{22}	-0.190930 (0.0000)[a]	α_{22}	-0.231892 (0.1495)
ψ_{21}	-0.864401 (0.1319)	β_{21}	0.336705 (0.0327)[a]
ψ_{22}	1.409698 (0.0000)[a]	β_{22}	0.332549 (0.0007)[a]
ψ_{23}	-0.006319 (0.3480)		
R-squared	0.988205		
Adjusted R-squared	0.988066		

[a] indicates significance at 5% confidence level

Source: Author's computation using E-Views 10

Results from the VARMA (2,2)-CCC-GARCH as shown in Table 15 suggest that the volatility of the All Share Index (ASI) of the Nigerian stock market is caused largely by its past shocks. The values of parameters $\phi21$ and $\phi22$ are used to measure shocks of the lagged values of the dependent variable on itself, and both are highly significant. This, however, is not a surprise for financial data with high volatility such as the stock exchange market. The model further suggests that the federal fund rate and money supply of the United States are not significant in explaining volatility in the All-Share Index of the Nigerian Stock Exchange Market. However, the exchange rate was shown to be highly significant. The parameter ψ_{22} is estimated as 1.409698 and it is statistically significant and positively signed. This indicates that a 1% increase in the Exchange rate will increase the ASI in the following month by approximately 1.41% *ceteris paribus*.

The variance equation measures the extent to which the current volatility goes into future volatility. When the summation of α_{21} and β_{21} values approximates to 1, it confirms the existence of volatility; 0.775444 + 0.336705 = 1.112149.

Table 14: Summary of VARMA (1,1)-BEKK-GARCH and VARMA (1,2)-DCC-GARCH results for All Share Index (ASI)

Mean Equation		
Parameters	**VARMA (1,1)-BEKK-GARCH**	**VARMA (1,2)-DCC-GARCH**
μ_2	16.95485 (0.2521)	20.55352 (0.2247)
ϕ_{21}	1.261125 (0.0000)[a]	1.242933 (0.0000)[a]
ϕ_{22}	-0.262272 (0.0000)[a]	-0.244069 (0.0000)[a]
ψ_{21}	-0.772817 (0.0994)	-0.862866 (0.1092)
ψ_{22}	1.328006 (0.0000)[a]	1.411040 (0.0000)[a]
ψ_{23}	-0.004731 (0.3917)	-0.005983 (0.3416)
Variance Equation		
C_2	0.513149 (0.5858)	1.274333 (0.3319)
α_{21}	0.734270 (0.0000)[a]	0.691605 (0.0000)[a]
β_{21}	0.828079 (0.0000)[a]	0.184959 (0.0023)[a]
β_{22}		0.398966 (0.0000)[a]
	R-squared - 0.988131	R-squared - 0.988168
	Adjusted R-squared - 0.987991	Adjusted R-squared - 0.988029

[a] indicates significance at 5% confidence level

Source: Author's computation using E-Views 10

Table 16 shows the results of the other two models as chosen from the standard model selection criteria as seen in Table 14. The VARMA (1,1)-BEKK-GARCH and VARMA (1,2)-DCC-GARCH models above did confer with the result of the VARMA (2,2)-CCC-GARCH model explained above. That implies that all the different approaches used in estimating VARMA–GARCH models in the paper have shown comparable results. They all proved the effects of the past volatility of ASI on itself. Also, the models have shown that the spillover effects of monetary policies from the United States specifically among the three policy variables i.e., federal fund rate, exchange rate and money supply, only the exchange rate is found to be significant. Hence, we can conclude that the spillover effects of the U.S. monetary policies on the Nigerian stock market is only present through the exchange rate channel. The All-Share Index (ASI) of the Nigerian Stock Market responds to a 1% increase in Exchange Rate in the following month by approximately 1.3% to 1.4% increase, *ceteris paribus*.

5. Conclusion

This paper examined the spillover effects of U.S monetary policies on the Nigerian stock exchange market between 1985 – 2020., taking in to account the U.S. conventional monetary policy (CMP) from 1985 to 2007 and unconventional monetary policy (UMP) from 2007 to 2020. Considering the volatile nature of the financial time series variables, the study used monthly data and employed BEKK-VARMA-CCC MGARCH model following relevant pre-tests to capture all possible spillover effect. The VARMA (2,1)-CCC-GARCH shows that changes in any of the three monetary policy variables i.e., the federal fund rate, exchange rate have a negative and significant spillover effect on the Nigerian market capitalization, while U.S. money supply displays a positive and significant spillover to Nigerian market capitalization. Furthermore, the spillover effect of U.S. monetary policies on Nigeria's All-Share Index (ASI) is insignificant. However, the U.S. exchange rate exerted a positive and highly significant effect on the All-Share Index (ASI).

Policy Implications

The presence of negative spillover effects could potentially expose the vulnerability of the Nigerian stock exchange market that could weaken the investors' confidence in the stock market since fragile investments could be directly affected by policy changes in powerful economies like the U.S. This may further cause a crowding out affect the industrial sector.

A positive change in exchange rate, however, will result in an appreciation in the value of market capitalization as expected, resulting to an increase in the value of stocks. It also serves as a good signal that the economy is doing well, which can also attract new investors, drawn by the rising incentives with the hope of maximizing profits. This will also affect all share index positively by increasing the rate of return on investments. Together, these will transmit a good signal and also boost productivity by providing more capital for the expansion of businesses, thereby translating to a healthy and booming economy. The opposite is likewise problematic, because a fall in the value of the Naira will erode the value of investments along with incentives. This will cause the size of the stock market to shrink and even dissuade prospective investors form investing in Nigeria's stock market.

Recommendations

Spillover effects of the United States monetary policy on the Nigerian stock market are proven to exist through the exchange rate channel. Thus, any improvement in the value of the Naira against the U.S. Dollar will result in a positive spillover effect on the Nigerian stock exchange market. It is therefore recommended that the Central Bank of Nigeria should focus on strengthening the exchange rate by pursuing a managed float exchange rate system in order to hedge the spillover effect of U.S. exchange rate on the Nigeria's stock market.
Nigeria can liquidate some of its foreign exchange assets including Treasury bills and retire the proceeds to Nigeria. This may not necessarily cause a depreciation in the dollar but would appreciate the value of Naira. The monetary authority can equally implement policies that will curb the increasing rate of inflation in order to make exports more competitive and increase the value of the currency in the long term. To achieve this, the fiscal and monetary authorities should pursue tighter fiscal and monetary policies.

The government should implement supply-side policies such as tax-cuts, among others. This will reduce costs of production and increase Nigeria's competitiveness globally, leading to an exchange rate regime that can hedge the spillover effects of the U.S monetary policy.

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