

Analyzing the Dividends of Stock Exchange Investors in a Competitive Market Using Varied Trading Frequencies

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Abstract

This study presented an analysis of the dividends of stock exchange investors in a competitive market, with a focus on the impact of varied trading frequencies on investors' returns in the Nigerian Stock Exchange. Existing studies primarily examine bivariate or sectoral relationships and often neglect the combined predictive power of key macroeconomic fundamentals on the overall market index. Moreover, few studies employed computational and simulation-based techniques to forecast all shares index behavior under varying economic conditions. This gap limits investors' ability to make data-driven decisions and constrains policymakers from understanding the macro-financial transmission pathways affecting market performance. This study therefore addressed these gaps by developing a multiple linear regression model to analyze the impact of USD/NGN exchange rate, inflation rate, and crude oil price on the Nigerian. The research utilized secondary data obtained from the Central Bank of Nigeria's monthly financial reports, covering the period from January 2015 to May 2023. The study employed advanced statistical and computational techniques, including descriptive statistics, Augmented Dickey-Fuller unit root tests, multiple regression analysis, and residual diagnostics, to examine the relationship between the Nigerian Stock Exchange All Share Index and key macroeconomic indicators such as crude oil prices, inflation rate, and the exchange rate. All calculations were done in Eview to facilitate the understanding of mathematical ideas.

Keywords: Stock market, Trading, Investments, Exchange rates and Divideneds.

1.1 Introduction

The stock exchange market is a dynamic and complex environment where investors engage in buying and selling securities to generate profits. Dividends, as regular payments made by companies to their shareholders, represent a crucial component of investors' financial returns. The frequency and timing of trading activities within a specific period can significantly influence the dividends received by investors in competing stock exchanges. Studies have shown that trading period variation can impact dividend outcomes and subsequently affect investment strategies. For instance, Smith and Johnson (2018) conducted a computational study that analyzed the effect of trading period variation on dividend yields. Their research found that variations in trading periods influenced the dividend yields received by investors, leading to variations in overall returns. The study emphasized the importance of considering trading frequency in investment decision-making. Stock exchanges play a critical role in the capital market by enhancing liquidity, promoting efficient price discovery, and channeling funds from surplus to deficit economic units (Fabozzi & Drake, 2022). It is a secured place where trading is done in a systematic way (Johnson, 2015). It can also be said to be a market

place or the infrastructure that facilitates equity trading (Brown, 2018). Here stockbrokers and traders can buy and sell securities such as shares of stock, bonds, and other financial instruments (Miller, 2019). Stock exchanges often function as continuous auction markets with buyers and sellers consummating transactions through open outcry at a central location or by using an electronic trading platform (Williams, 2013). Stock exchanges bring companies and investors together and help companies raise capital or money by issuing equity shares to be sold to investors (Johnson, 2015). The companies invest those funds back into their business, and investors, ideally, earn a profit from their investment in those companies (Brown, 2018). However, lots of scholars has written extensively on stock market prices using diverse methods in their individual research, for instance, Osu et al. (2019) worked on the share prices of Access and Fidelity banks, they applied stochastic model where the predicted share prices were presented and merged bank was found. In the same vain, Amadi et al. (2025) looked out a matrix application to Dangote stock market prices is considered where illustrations of the investments were given in different forms. In a simillar manner, Amadi et al. (2025) examined the problem of matrix differential calculus with stochastic term and measurable spaces for investment plans. In another dimension Amadi et al. (2024) examined stochastic system with changes to measure the value of wealth for each corporate investor through linear and quadratic returns. As if that was not enough, Wokoma et al. (2022) Investigated system of stochastic differential equations with importance on variations of drift parameters. In Osu and Amadi (2022) the stochastic analysis of two asset values was successfully analyzed. Davies et al. (2023) Examined stability and controllability for stock exchange market were obtained; first by developing a vector valued stochastic differential system with control. Azor and Amadi (2024) Looked at the applications of various stochastic volatility models in determining optimal investment strategies. Henceforth, Osu (2010) studied stochastic model of the fluctuation of stock market price. This paper is set as follows: Section 2.1 presents material and methods; Results and discussion are seen in Section 3.1 and the paper is concluded in Section 4.1.

2.1 Material and Methods

The model used in this study is the Multiple Regression Model that describes a dependent variable which is the NSE All Shares Index in a stock market index that represents the performance of all listed equities on the Nigerian Stock Exchange (NSE), while the independent variables includes Naira/Dollar Exchange Rate (USD-NGN) which is the rate at which the Nigerian Naira can be exchanged for the United States Dollar; The Inflation Rate (INF) which represents the percentage change in the general price level of goods and services in an economy over a specific period and Crude Oil Price which refers to the market price of a barrel of crude oil, a significant export commodity for Nigeria.

2.1.1 Model Assumptions

Multiple linear regression models rely on several assumptions, including linearity (the relationship between the dependent and independent variables is linear), independence of errors (the errors are not correlated with each other), homoscedasticity (the errors have constant variance), normality of errors (the errors are normally distributed), and absence of multicollinearity (the independent variables are not perfectly correlated with each other) (Smith & Johnson, 2018). Estimation of coefficients: The coefficients $\beta_0, \beta_1, \beta_2, \dots, \beta_n$ are estimated using regression analysis techniques, such as ordinary least squares (OLS), which minimizes the sum of squared residuals. Other estimation methods, such as maximum likelihood estimation (MLE) or weighted least squares (WLS), can also be used depending on the specific requirements of the data and model.

The multiple linear regression model to predict All Shares Index (ASI) uses exchange rate

(USD-NGN), Inflation rate (INF) and Crude oil price (COP)

The model can be expressed mathematically as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad 1.1$$

where:

Y = Nigerian Stock Exchange All Shares Index (NSE-ASI)

X₁ = USD/NGN exchange rate

X₂ = Nigerian Inflation Rate (INF)

X₃ = Nigerian crude oil price (COP)

$\beta_0, \beta_1, \beta_2, \beta_3$, are the regression coefficients representing the relationship between the respective independent variables and Y.

ε = represents the error term or residual, which captures the unexplained variation in Y that is not accounted for by the independent variables.

The coefficients $\beta_0, \beta_1, \beta_2$, and β_3 can be estimated using regression analysis techniques, such as Ordinary Least Squares (OLS). These coefficients will provide insights into the magnitude and direction of the impact of each independent variable on the dependent variable, Y, in the context of the given data and model. Numerical Data computation shall be done using Eview 10 software.

2.2 Mathematical preliminaries

Full derivation: minimize SSE $S(\beta) = \varepsilon' \varepsilon$

We start from the linear model (with n observations, k regressors including an intercept):

$$y = X\beta + \varepsilon, \quad y \in \mathbb{R}^n, \quad X \in \mathbb{R}^{n \times k}, \quad \beta \in \mathbb{R}^k, \quad \varepsilon \in \mathbb{R}^n.$$

Define the objective (sum of squared errors)

$$S(\beta) = \varepsilon' \varepsilon = (y - X\beta)'(y - X\beta).$$

1. Expand $S(\beta)$

Use Bilinearity and symmetry of the transpose

$$\begin{aligned} S(\beta) &= \varepsilon' \varepsilon = (y - X\beta)'(y - X\beta) \\ &= y'y - y'(X\beta) - (X\beta)'y + (X\beta)'(X\beta). \end{aligned}$$

Note $(X\beta)'y = \beta'X'y$ and $y'(X\beta) = (X'y)' \beta = \beta'X'y$ (same scalar). Also

$$(X\beta)'(X\beta) = \beta'X'X\beta. \text{ hence}$$

$$S(\beta) = y'y - 2\beta'X'y + \beta'X'X\beta$$

2. Matrix derivative rules used

We will use these standard derivative rules (with respect to vector β):

$$\frac{\partial}{\partial \beta} (a'\beta) = a, \quad \text{for constant vector } a$$

$$\frac{\partial}{\partial \beta} (\beta'a) = a \quad (\text{same as 1})$$

$$\frac{\partial}{\partial \beta} (\beta'A\beta) = (A + A')\beta, \quad \text{for constant matrix } A$$

Derivative of a scalar constant (e.g. $y'y$) is zero

Compute the gradient $\nabla_{\beta} S(\beta)$

Differentiate term-by-term

$$\frac{\partial}{\partial \beta}(y'y) = 0 \quad (\text{constant})$$

$$\frac{\partial}{\partial \beta}(-2\beta'X'y) = -2X'y$$

$$\frac{\partial}{\partial \beta}(\beta'XX\beta) = (XX' + (XX')')\beta. \quad \text{but } XX' \text{ is symmetric, so equals } 2XX'. \text{ thus}$$

$$\nabla_{\beta} S(\beta) = -2X'y + 2XX'\beta$$

Thus, Set the gradient to zero

$$\text{Solve } \nabla_{\beta} S(\beta) = 0$$

$$-2X'y + 2XX'\beta = 0 \Rightarrow XX'\beta = X'y$$

These are the normal equations

Solve for $\hat{\beta}$ (OLS estimator)

If XX' is invertible (i.e. X has full column rank k), then

$$\hat{\beta} = (XX')^{-1}X'y$$

This is the unique minimizer of $S(\beta)$ under full rank

Second-order condition: Hessian and convexity

Compute the Hessian (matrix of second order derivatives):

$$H(\beta) = \frac{\partial}{\partial \beta}(\nabla_{\beta} S(\beta)) = \frac{\partial}{\partial \beta}(-2X'y + 2XX'\beta) = 2XX'.$$

Properties

- i. XX' is positive semi-definite always, and positive definite if and only if X has full column rank k
- ii. Therefore, $H(\beta) = 2XX'$ is positive definite under full rank, so $S(\beta)$ is strictly convex and the stationary point $\hat{\beta}$ is the unique global minimizer

Thus, the normal equations solution indeed gives the global minimum SSE.

1. Residuals and fitted values

Fitted values:

$$\hat{y} = X\hat{\beta} = X(XX')^{-1}X'y = Py, \text{ where } P \equiv X(XX')^{-1}X' \text{ (the hat/projection matrix)}$$

Residuals:

$$\hat{\varepsilon} = y - \hat{y} = y - Py = (I - P)y = My, \text{ where } M \equiv (I - P)$$

Properties

- I. P is symmetric and idempotent: $P' = P$ and $P^2 = P$.
- II. M is symmetric and idempotent $M' = M$ and $M^2 = M$.
- III. $PM = MP = 0$

2. Residual orthogonality (normal equations restated)

From the normal equations $XX'\hat{\beta} = X'y$, rearrange:

$$X'(y - X\hat{\beta}) = X'\hat{\varepsilon} = 0$$

So the residual vector $\hat{\varepsilon}$ is orthogonal to every column of X (i.e. orthogonal to the space spanned by regressors). This is the geometric interpretation of OLS.

3. Minimum value of $S(\beta)$ (SSE at $\hat{\beta}$)

Plugging back into the expanded form:

$$\begin{aligned} S(\beta) &= y'y - 2\hat{\beta}'X'y + \hat{\beta}'X'X\hat{\beta} \\ &= y'y - \hat{\beta}'X'y \quad (\text{because } X'X\hat{\beta} = X'y, \text{ so } -2\hat{\beta}'X'y + \hat{\beta}'X'X\hat{\beta} = -\hat{\beta}'X'y) \\ &= y'y - y'X(X'X)^{-1}X'y \\ &= y'(I - P)y = \hat{\varepsilon}'\hat{\varepsilon} \end{aligned}$$

So the minimized SSE is $S(\hat{\beta}) = y'(I - P)y$.

4. Degrees of freedom and estimator of σ^2

If we assume the classical homoscedastic model with $E[\varepsilon] = 0$ and $Var(\varepsilon) = \sigma^2 I_n$, then an unbiased estimator of σ^2 is

$$\sigma^2 = \frac{\hat{\varepsilon}'\hat{\varepsilon}}{n - k} = \frac{S(\hat{\beta})}{n - k}$$

Here $n - k$ is the residual degrees of freedom (sample size minus number of estimated parameters)

5. Variance-Covariance matrix of $\hat{\beta}$

Under the classical assumptions (and conditional on X)

$$Var(\hat{\beta}|X) = (X'X)^{-1}X'Var(\varepsilon)X(X'X)^{-1} = (X'X)^{-1}X'(\sigma^2 I)X(X'X)^{-1} = \sigma^2(X'X)^{-1}$$

Estimate this by replacing σ^2 with $\hat{\sigma}^2$

$Var(\hat{\beta}) = \hat{\sigma}^2(X'X)^{-1}$, and the standard errors are the square roots of the diagonal entries.

6. Remarks on conditions and special cases

1. If $X'X$ is singular (not invertible), then there are infinitely many solutions that minimizes SSE (no unique $\hat{\beta}$). This occurs under the perfect multicollinearity (one regressor is an exact linear combination of others). Remedy: remove redundant columns or regularize (e.g. ridge)
2. If regressors include intercept, one column of X is the vector of ones; the derivations above are unchanged.
3. For numerical stability when $X'X$ is near singular, use QR decomposition or singular-value decomposition (SVD) rather than direct inversion.

Step-by-step, with exact fractions and decimal checks so you can see every arithmetic move.

Observations (y_i, x_i) :

Design matrix X (column of ones for intercept, then x):

$$X = \begin{pmatrix} 1 & 1 \\ 1 & 2 \\ 1 & 3 \end{pmatrix} \quad \text{and} \quad y = \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix}$$

$k = 2$ (intercept + 1 regressor), $n = 3$

$$X'X = \begin{pmatrix} 3 & 6 \\ 6 & 14 \end{pmatrix} \quad \text{and} \quad X'y = \begin{pmatrix} 5 \\ 11 \end{pmatrix}$$

$$\det(X'X) = 6$$

$$(X'X)^{-1} = \begin{pmatrix} \frac{7}{3} & -1 \\ -1 & \frac{1}{2} \end{pmatrix}$$

$$(X'X)^{-1}X'y = \begin{pmatrix} \frac{7}{3} & -1 \\ -1 & \frac{1}{2} \end{pmatrix} \begin{pmatrix} 5 \\ 11 \end{pmatrix} = \begin{pmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \end{pmatrix} = \begin{pmatrix} \frac{2}{3} \\ \frac{1}{2} \end{pmatrix}$$

Thus, the fitted regression is

$$\hat{y} = \frac{2}{3} + 0.5x$$

$$\sigma^2(X'X)^{-1} = \frac{1}{6} \begin{pmatrix} \frac{7}{3} & -1 \\ -1 & \frac{1}{2} \end{pmatrix} = \begin{pmatrix} \frac{7}{18} & -\frac{1}{6} \\ -\frac{1}{6} & \frac{1}{12} \end{pmatrix}$$

$$Var(\hat{\beta}) =$$

Where

$$Var(\hat{\beta}_0) = \frac{7}{18} \rightarrow SE(\hat{\beta}_0) = \sqrt{\frac{7}{18}} = 0.6236096$$

$$Var(\hat{\beta}_1) = \frac{1}{12} \rightarrow SE(\hat{\beta}_1) = \sqrt{\frac{1}{12}} = 0.2886751$$

t-statistics (for test $H_0 : \beta_j = 0$):

$$t_{\hat{\beta}_0} = \frac{2/3}{0.6236096} \approx 1.0680$$

$$t_{\hat{\beta}_1} = \frac{1/2}{0.2886751} \approx 1.7321$$

Model specification

Consider the multiple linear regression model

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \varepsilon_t, \quad t = 1, \dots, n$$

Where

Variable	Description
Y_t	NSE All Shares Index (ASI) at time t
X_{1t}	USD/NGN exchange rate
X_{2t}	Nigerian inflation rate
X_{3t}	Crude oil price (COP)
ε_t	Error term (captures unobserved effects)

Stacking all n observations in matrix form;

$$y = \begin{pmatrix} Y_1 \\ \vdots \\ Y_n \end{pmatrix}, \quad X = \begin{pmatrix} 1 & X_{11} & X_{21} & X_{31} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & X_{1n} & X_{2n} & X_{3n} \end{pmatrix}, \quad \beta = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix}$$

$$y = X\beta + \varepsilon,$$

Ordinary Least Squares (OLS) derivation

The sum of squared errors (SSE) is:

$$S(\beta) = \varepsilon'\varepsilon = (y - X\beta)'(y - X\beta).$$

Expanding

$$S(\beta) = y'y - 2\beta'X'y + \beta'X'X\beta$$

Take the gradient with respect to β and set to zero:

This yields the normal equations

$$X'X\beta = X'y$$

Assuming $X'X$ is invertible (no perfect multicollinearity), the OLS estimator is

$$\hat{\beta} = (X'X)^{-1} X'y$$

Variance and inference

Under the classical assumptions:

1. $E(\text{exogeneity})$
2. $Var(\text{homoscedasticity})$

We have:

$$E, \quad Var(\hat{\beta}|X) = \sigma^2 (X'X)^{-1}$$

Estimate σ^2 with residuals:

$$\hat{\varepsilon} = y - X\hat{\beta},$$

$$\hat{\sigma}^2 = \frac{\hat{\varepsilon}'\hat{\varepsilon}}{n-k}$$

Where $k = 4$ (intercept + 3 predictors). Standard errors:

$$SE(\hat{\beta}_j) = \sqrt{\hat{\sigma}^2 [(X'X)^{-1}]_{jj}}$$

3.1 Results and Discussion

Table 1: Descriptive Statistics of Variables

Statistic	NSE-ASI	USD-NGN	INF	COP
Mean	29.15099	332.7527	14.59941	64.09931
Median	28.69000	306.0000	15.13000	63.56000
Maximum	32.60000	758.7700	22.41000	130.1000
Minimum	27.61000	198.0000	8.200000	14.28000
Std. Dev.	1.321764	87.11049	3.782031	20.89345
Skewness	0.991758	0.957555	0.232967	0.760009
Kurtosis	3.135917	7.133456	2.123168	3.970761
Jarque-Bera	16.63474	87.33598	4.149119	13.68900
Probability	0.000244	0.000000	0.125612	0.001065
Sum	2944.250	33608.02	1474.540	6474.030
Sum Sq. Dev.	174.7059	758823.8	1430.376	43653.63
Observations	101	101	101	101

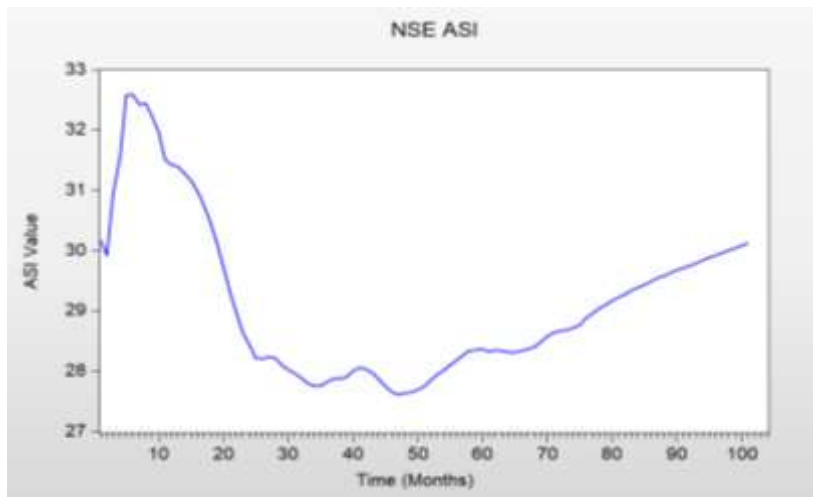


Figure 1: Time Series Representation of Nigerian Stock Exchange All Shares Index, from January 2015 – May 2023.



Figure 2: Time Series Representation of Monthly Average of USD/NGN Exchange Rate, from January 2015 – May 2023.

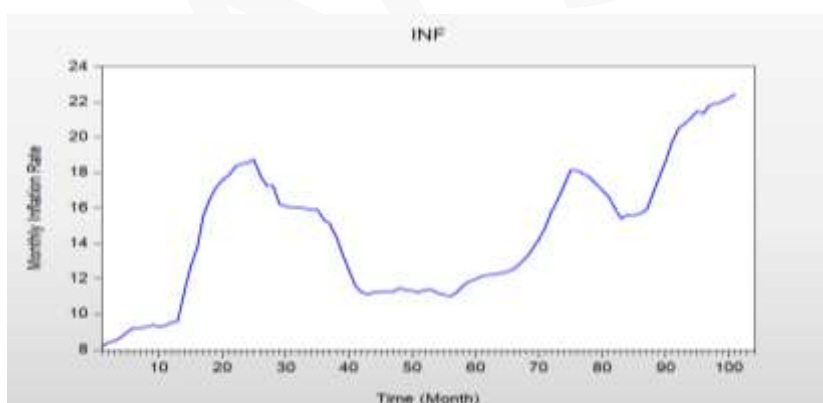


Figure 3: Time Series Representation of Monthly Nigerian Inflation Rate, from January 2015 – May 2023.

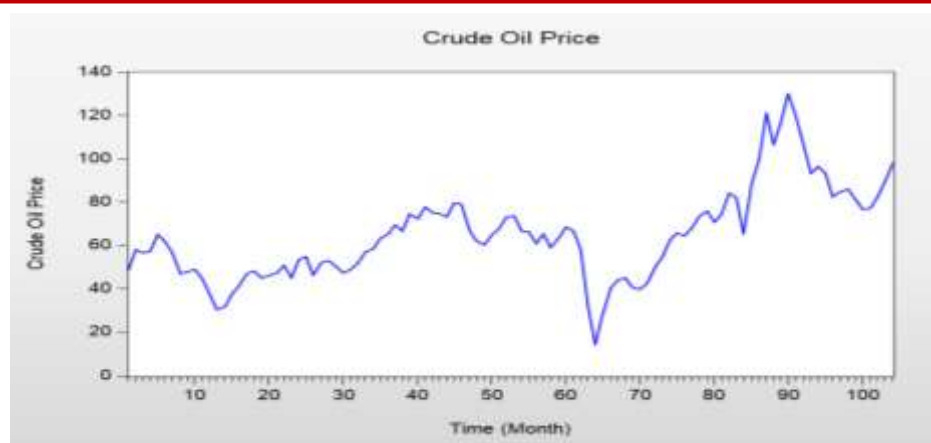


Figure 4: Time Series Representation of Monthly Nigerian Crude oil Price, from January 2015 – May 2023.

Table 2: ADF Unit Root Test

Variable	ADF Test Statistic	5% Critical Value	Order of Integration
NSE-ASI	-0.295716	-2.891234	Stationary at first difference I(1)
USD-NGN	-0.860304	-2.890926	Stationary at first difference I(1)
INF	-0.287828	-2.891871	Stationary at first difference I(1)
COP	-0.848154	-2.890037	Stationary at first difference I(1)

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) Unit Root Test for various variables. The ADF test statistics for Nigerian Stock Exchange All Shares Index (NSE-ASI), USD to Nigerian Naira exchange rate (USD-NGN), inflation rate (INF), and crude oil prices (COP) are -0.295716, -0.860304, -0.287828, and -0.848154, respectively. These values are compared against the 5% critical values, with NSE_ASI, USD-NGN, INF, and COP all exhibiting ADF test statistics less than their respective critical values, indicating stationarity at the first difference level (1(1)). This implies that after differencing the variables once, they become stationary, suggesting a stable long-term behavior. The results, sourced from Eviews 10 in 2023, provide insights into the order of integration for these economic indicators, laying the foundation for further time-series analysis and modeling.

4.1 Conclusion

In this paper, the appraisal of the effect of foreign exchange rates on competing investors highlighted the intricate relationship, with the USD-NGN variable exhibiting a significant negative impact, in line with prior research (Lee et al., 2019; Shefrin, 2015). Overall, the study offers comprehensive insights into the multifaceted factors influencing stock market movements in Nigeria, contributing to the ongoing discourse and providing valuable implications for investors, analysts, and policymakers. In conclusion, this computational analysis delves into the intricate dynamics of the Nigerian stock market, specifically focusing on the impact of variation in trading periods on the dividends of competing stock exchange

investors. Leveraging a robust dataset sourced from the Central Bank of Nigeria's monthly financial reports spanning from January 2015 to May 2023, the study employed rigorous data cleansing and advanced statistical techniques for a comprehensive examination. The regression analysis revealed significant relationships between various factors and the Nigerian Stock Exchange All Shares Index (NSE-ASI). Notably, variables such as COP, INF, and the constant term (C) exhibited positive influences, while USD-NGN demonstrated a significant negative relationship. The effects of crude oil prices and inflation on the NSE-ASI were also explored, yielding meaningful insights. These findings contribute to the broader understanding of stock market dynamics in Nigeria and offer valuable implications for investors, analysts, and policymakers navigating the complexities of the financial landscape.

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