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The Dependence Structure Between Stock Market Returns and Short-Term Interest Rates in Nigeria (Copula Analysis)

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Abstract: The objective of the paper was to determine the dependence structure between stock market returns and short-term interest rates in Nigeria using a copula-based statistical model. Daily price data of the All-Share Index (ASI) from the Nigeria Stock Exchange and short-term interest rate, represented by the prime lending rate from March 1999 to December 2001 and the Monetary Policy Rate (MPR) from January 2002 to December 2022 from the Central Bank of Nigeria, were collected for the study. Student's t-copula was selected for the study as it considers the variables' non-linear dependencies and tail risks, which were not accounted for in previous research on subjects that used traditional linear statistics models. Short-term interest rates were relatively stable in the years of the study, while stock returns show high volatility, non-normal characteristics, and significant zero-peaked returns. The copula student's t-test, along with maximum likelihood estimation and subsequent goodness-of-fit tests, shows minimal tail dependence between the variables. This means that stock market return does not significantly depend on the short-term interest rate in Nigeria, and changes in short-term interest rates only explain a small part of the variation in stock market returns. Validity tests using the rolling window correlations and contour plots support the above findings. The study contributes to an in-depth understanding of the Nigerian market dynamics and highlights the importance of using advanced statistical analysis techniques for risk assessment, investment, and economic policy decision-making in Nigeria's financial markets.

Keywords: *Copula, Dependence, Stock Returns, Short Term Interest Rate, All Share Index, Monetary Policy, Nigeria.*

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I. INTRODUCTION

➢ *Background to the Study*

In recent times, the relationship locally (Nigeria and dependence between stock market returns and interest rates both) and internationally, have become stronger than in the pasts, as evidenced by research conducted. Investors generally believe that macroeconomic activities have a large impact on the volatility of stock prices. Macroeconomic determinants can be a standard for the investors to forecast the performances of the stock market[1,2], and the entire economy's forces do provide some significant positive as well as negative effects on stock market performance, reflecting the behaviour of the variables[3,4] .

Interest rates are often considered when making investment decisions because the financial sector is connected to the real sector of the economy. For example, the lending rate, which is the cost of capital, has direct effects on investment. High lending rates discourage borrowing for investment. Also, a high saving rate encourages savings, which means more lent funds for investments. Specifically, Short-term interest rate adjustments by the central bank can lead to immediate market reactions, impacting stock prices and trading volumes[51]. These changes can influence investors' behaviour and their willingness to invest in equities, as they weigh the relative attractiveness of stocks and fixed-income investments, such as bonds[5]. Moreover, long-term interest rates, influenced by factors like inflation and government bond yields, can affect the discount rates applied to future corporate earnings [6]. The relationship between the variable

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does not only appeal to investors, but to a host of other stakeholders. Policy makers and financial institutions rely on this relationship to make informed economic and financial decisions.

Irrespective of the importance of the relationship, the proper measurement and modelling of the dependence of stock market return and interest rate has been a challenging issue in the empirical macro-finance literature. Review of relevant journals on macroeconomics stock market return dependency shows that critical values from less sophisticated statistical models like ARDL, OLS, Granger Causality, Vector Error Correction Model (VECM), etc., were used in the analysis of data. However, financial markets are complicated, and there is need for a more complicated model to analyze the dependency between the two variables. The improper measurements, modelling, and analysis of the collected data has resulted in conflicting conclusions, especially for research conducted with Nigerian data and using traditional correlation methods.

This paper uses All Share Index (ASI) return and short-term interest rate data from the Nigeria stock exchange (NSE) and Central Bank of Nigeria (CBN) for the period from March 1996 to December 2022 to close the above identified gap by using critical values from copula models to analyse the dependence structure between Nigeria's stock market returns and short-term interest rates using copula analysis. The paper also seeks to uncover the nature, strength, and asymmetry of their relationship, providing insights that can guide investment strategies, risk management, and monetary policy formulation in Nigeria's financial markets.

The copula model statistically models the relationship between two or more random variables. This model describes variable dependency without marginal distributions, allowing for a more flexible and accurate representation of the relationship between the variables compared to traditional correlation measures[7]. The key advantage of the copula model over other models is that it accounts for non-linear relationships between variables [8], which are often present in financial data such as the data used in this study. By capturing these complex dependencies, the copula model can provide a more accurate assessment of risk and help in making better decisions in portfolio management, asset pricing, and risk assessment[9].

This paper is divided into four sections. Section one introduces stock market return and interest rate in Nigeria. Section two reviews the concept of this study, presents theories that support the concept, and empirically analyses the relevant literature. Research methodology of the paper is presented in section three, while section four is the concluding section of the paper.

➢ *Research Objective*

To investigate the nature and strength of the dependence structure between Nigeria's stock market returns and short-term interest rates

➢ *Research Question*

The research question of the paper is as stated below: What is the nature and strength of the dependence structure between Nigeria's stock market returns and short-term interest rates?

➢ *Hypothesis*

Based on the research questions stated above, the hypothesis of the research is stated as follows:

- **H_0:** There is no significant dependence structure between Nigeria's stock market returns and short-term interest rates.
- **H_1:** There is a significant dependence structure between Nigeria's stock market returns and short-term interest rates.

II. LITERATURE REVIEW

➢ *Conceptual Review*

- *Share Market Return*

Stock market return is the profit or loss an investor made over a specified period from investing in stocks. Stock market return is generally measured as a percentage and is used to assess the performance of individual stocks, mutual funds, or entire markets. Investors most times depend on stock market returns to evaluate the success of their investment strategies, determine risk levels, and make informed decisions about buying or selling securities [10].

There are several phases regarding the development of stock market returns analysis, such events influence the shape and decisions regarding setting up an appropriate interest rates and offering specific insights into the movement of stock returns within the specific conditions. Some of the events are the great depression of 1929 to 1941, post-World War II economic situation of 1945 to 1948, technological development and advancement, the stagflation of the 1970s, the stock market bubble of 1995 to 2000, financial crisis from mid-2007 to early 2009., COVIC 19 epidemic, and many more [11].

Stock market return is measures using the rate of returns, which refers to a minimum level of projected return that an investor expects to invest in a specific stock or asset within a specified period, considering the level of risk associated with the stock or asset. The rate signifies the foregone potential for investing in the most rewarding option available elsewhere with identical risk levels. The rate of return serves as a benchmark for receiving adequate compensation for the risk associated with investing in the asset, including the opportunity cost. If the investor's anticipated return surpasses the necessary return, the asset will be perceived as undervalued since it is projected to yield more than adequate compensation for the risk associated with the asset. Conversely, if the anticipated profit from the asset is lower than the necessary profit rate, the item will seem to be priced too high[12].There are several types of rates of return such as nominal rate of return, real rate of return, expected rate of return, and required rate of return. Stock returns can

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also be measured using total return, excess returns, arithmetic means return, geometric mean return, capital gain return, holding period return and many more.

- *Interest Rate*

Generally, interest rates are the cost of borrowing money and represents the compensation received by lenders for taking on the risk of lending money to borrowers. Interest rates are expressed as a percentage of the principal amount borrowed and can be fixed or variable depending on the terms of the agreement [13].Another common definition of interest rate is the rate of the return on investment. Investors investing in any form of asset e.g. bonds, stocks, or other financial instruments (savings, Term Deposit, Commercial papers, treasury bills, and many more), will expect a return in the form of interest rate. Like the interest rate on borrowing, rate of return on investment can be fixed or variable and is expressed as percentage of the principal amount invested [14].

Interest rate is a monetary policy, and the central banks of every country use monetary policy and other fiscal policies like bank rate, open market operation (OMO), re-discount rate, etc. to control inflation and economic growth. In times of inflation and expanding economy, the central banks may raise interest rates to curb inflation. Conversely, when the economy activities and inflations are low, central banks may lower interest rates to stimulate economic growth[15].

➢ *Theoretical Framework*

Asset pricing models like the Capital Pricing Asset Model (CAPM), Arbitrage Pricing Theory (APT), and the Fama and French model[16] provide the necessary framework for the study of stock return dependency, especially the linkage between stock returns and macroeconomic indicators. The CAPM through the constant expected returns hypothesis assumes that an asset's return over time is normally distributed with a constant mean variance. While APT, and the Fama and French three factor model assumes that stock returns can be modelled as a linear function of various macroeconomics factors and company conditions, where sensitivity to changes in each factor is represented by a factor specific beta coefficient.

The behaviour of Stock Market Price, a paper by Eugene F. Fama published in 1965 provides a comprehensive literature on the theories that guides the behaviour of stock prices. In the paper, pattern of stock price movement was presented as having two types of behaviour, (a) stock market analyst trying to predict the market trends from past information, and (b) Random Walk theory. Random walks theory supports the market efficiency hypothesis, whereas the studies on stock return dependency and co-movement is conducted mainly to invalidate the efficient market hypothesis. A stock market is fully efficient if stock price cannot be predicted using any relevant available information, and no profit opportunities are left unexplained. In an efficient market there exist a large number, profit motivated investors competing with each other to predict future market value of securities traded in the market, in the market the current market value of the securities fully reflects in the stock price and such information are freely available to all the market players[17].

The efficient market hypothesis provides a foundation for examining whether changes in short-term interest rates influence stock market returns in Nigeria. If dependence exists, it may indicate inefficiencies in the Nigerian stock market, contradicting the hypothesis.

➢ *Empirical Review of Related Literatures*

Empirical studies on subjects demonstrated a substantial interrelationship between macroeconomic variables, including interest rates, and stock returns in Nigeria. However, the use of copula analysis to characterise the dependence structure between Nigeria's stock market returns and short-term interest rates is still inadequately examined. Addressing this gap is this paper is useful for a more sophisticated comprehension of the non-linear and tail relationships among the variable and providing significant insights for investors, policymakers, and financial analysts in Nigeria.

As stated above,[18] is one of the few studies that was conducted using data from Nigeria. The study analyses the relationship between the Nigerian stock market and other international stock markets, with the aimed of studying the co-movement and dependence structures. Student t-copula was used in the study and the model was found to perfectly fit the data and emerged as the model to describe pairwise dependence between Nigerian Stock index against other nine selected world's stock markets. Other researches were papers that uses data from developing countries, such as the paper by Kim, Tabacu, and Jung[19] , the paper unveils the dependence structure between United States stock prices, crude oil prices, exchange rates, and United State interest rates. Linear and non-linear estimation methods, e.g. quantile regression and the quantile-copula approach were used in the paper to analyse data collected for the period from 1998–2017. The paper findings were that there is a positive relationship between the dollar value and the S&P 500 stock price, with the exception of the lower and upper tails of the stock return distribution. Further evidence in the paper shows the dependence structure between other asset returns, and that stock returns are negatively related to oil prices but positively to United State interest rates. Findings in the study was sufficient to conclude that financial assets are linked and have implications for risk management and monetary policy.

There are, however, lot of materials using traditional correlation statistic modelling method to examine the relationship between asset return and interest rate. See table below:

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Table 1 Literatures with Traditional Correlation Statistic Modelling Method

S/N	Author's Name & Year	Research Title	Statistic Model and Findings
1	Alugbuo and Chika (2020)[20]	Monetary policy and stock market performance: Evidence from Nigeria Stock Exchange Market.	Lending interest rate has positive relationship with ASI in both the short and long term, Treasury Bill rate was negatively related to the All-share index in short term and positively related in the long run.
2	Kolapo, Oke, and Olaniyan (2018)[21]	Unravelling the Impact of Macroeconomic Fundamentals on Stock Market Performance in Nigeria: An ARDL-bound Testing Approach	ARDL was used to test the relationship between macroeconomic variables (interest rates included) and stock market performance. It was noted in the paper that interest rates were positively related to stock market performance and there was a long-term relationship (co-integration) between macroeconomic variables and stock market performance.
3	Umezurike, Echekoba and Ananwude (2019)[22]	Does Monetary policy affect stock market return? Recent evidence from the Nigerian Stock Exchange (1986-2018)	Changes in Monetary policy does not significantly affect stock market return in Nigeria. Specifically, in the long run, monetary policy rate is not related to stock market return in Nigeria, while in the short run, monetary policy rare is negatively insignificant to stock market return.
4	Babangida and Khan (2021)[23]	Effect of monetary policy on the Nigerian Stock Market: A smooth transition autoregressive approach.	Smooth Transition Autoregressive Model (STAR) was used in the paper and considered the bear and bull market in the analysis. In the findings, there was evidence of nonlinear effect of interest rate on the Nigeria stock market. MPR (lagged) and treasury bills (lagged) were found to have significant positive effects on stock returns in the bear market, while treasury bill (without lag) was positively related to stock returns. In the bull market, treasury bill (lagged) was significantly negative, while treasury bill (not lagged) was positively related to stock returns.
5	Ogbonna and Ejem (2020)[24]	Do Monetary Policy Instruments Influence Capital Market Returns in Nigeria?	Monetary has a significant relationship with the performance of the Nigerian capital market. Monetary policy rate was negatively correlated with ASI. The Coefficient and t-statistics were negative in terms of both ANOVA and ARDL (short run), however, in the long run the relationship between MPR and Stock return was found to be positive. In addition, the paper specified that the best model for predicting stock return is the model that has lagged value of dependent variables as additional regressors.
6	Temuhale and Achugbu (2019)[25]	Effects of Macroeconomic Variables on Stock Market Returns in Nigeria (1986-2016).	Macroeconomic variables have predictive power on stock market performance in the Nigeria stock market. Autoregressive Distributed ag (ARDL) bond testing and cointegration techniques were used to the analysis and the result was that inflation, exchange and interest rates have a positive but insignificant statistical effect.
7	Abu and Ibekwe (2023)[26]	Macroeconomic Determinants of Stock Market Performance in Nigeria	ARDL statistical model was used to analyze secondary data from the period from 1999 to 2021 and the result was that interest and exchange rates do not significantly affect the short- and long-term performance of stock in the stock exchange. In addition, the cointegration analysis specified that there is a positive relationship between interest rate and stock market return and recommended that the government should implement policies to maintain price stability to enhance stock performance in the exchange.
8	Udo, Odey and Jacob (2022)[27]	Effects of Selected Macroeconomic variables on stock market performance in Nigeria.	ARDL statistical model was used in the study and result was that gross domestic product, broad money supply, exchange rate, and savings interest rate have a positive effect on stock price and return in the Nigeria stock market, while the effect of inflation was negative.

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9	Chola (2024)[28]	The Effect of Selected Macroeconomic Factors on a Stock Market Performance in Zambia.	The study findings were that interest rates are one of the major determinants of stock return in the country because of the strong and significant relationship. The direction or predictive power of interest rate was not provided in the study, rather the effect was stated as being either negative or positive.
10	Babatunde, Igboeli, Balugun, Oladipo, Babalola, Olasina and Tella (2020)[29]	Framework for an Agent-Based Model for Stock Price Prediction in Nigeria.	Several models such as Autoregressive integrated Moving Neural Network (ARIMA), Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and Artificial Neural Network (ANN) were used in this paper to predict stock return and Mean Absolute Error (MAE) Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) to test the power of the predictive equation. The findings of the analysis showed that the stock selected for the study can be predicted with 90 per cent accuracy.

Source: Researchers 2025

III. METHODOLOGY

➢ *Population of the Study*

The population of the study are all shares listed in the Nigeria stock exchange for the period of 26 years from 1996 to 2022. As of 2022 (end of the first quarter), there were 457 listed securities in the exchange and with market capitalization value of =N=47, 930.86 trillion (USD 114.9 trillion) [30].

➢ *Sample and Sampling Techniques Simple Random*

As stated above, shares of stock in the market are group into indices which comprises of industry and sector performance indices. Daily price data of the All-share Index which tracks the general market movement of all listed equities on the NGX is used in this paper to calculate the price return.

Table 3.1 below present market capitalization of the ASI indices in the NGX for the period, 2021, 2022 and 2023.

Table 2 Market Capitalization of ASI from 2021 to 2023

S/nos	Indices	2021		2022		2023	
		Market Cap (NGN' Trillion)	%	Market Cap (NGN' Trillion)	%	Market Cap (NGN' Trillion)	%
1	ASI	222.97	18.29	279.15	14.97	409.18	16.35
2	Others	996.26		1,585.88		2,093.81	
	Total	**1219.23**		**1865.33**		**2502.99**	

Source: NGX fact sheet, 2021, 2022 and 2023[31]

➢ *Method of Data Collection*

Secondary stock market prices and short-term interest rates, sourced from the Central Bank of Nigeria (CBN) and Nigeria Stock Exchange (NGX), is used in the study. Stock price return are daily closing prices of the All-share index (ASI) for the period from March 1996 to December 2022. The average stock price is used to obtain the rate of return and then converted to monthly stock return. Short term interest rate is proxy by the prime lending rate (minimum) for the period from March 1996 to December 2001, and MPR for the period December 2001 to December 2022. The annual prime lending rate (minimum) and MPR is converted to monthly rate and used in the regression equation.

➢ *Method of Data Analysis and Model Specification*

- *Dependent Variable*

The rate of return is used in the computation of market returns for the paper. In the computation, dividend is ignored, and the returns are not cumulative. See below the rate of return formula.

$$\text{Rate of return } (r) = \frac{(P_f - P_i) + D}{P_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where P_f is the end of day price, P_i is the beginning of the day price, and *'D'* is the dividends received (not included in the computation).

- *Independent Variable*

The independent variable for this study is the monetary policy rate. The MPR was introduced in Nigeria in January 2002; therefore, from March 1996 to December 2001, the prime lending rate (minimum) of commercial banks is used as proxy for the MPR, and from December 2001 to December 2022, the MPR is used. Monthly rate of return is obtained by averaging the daily for a particular month. As the MPR rates are stated in annual rate, an effective monthly rate (with formula stated below) is used to obtain a compatible rate to match with the monthly ASI and NGX30 price returns.

Monthly Interest rate (^{r}_month) = ⟦(1+r)⟧ ^ (1/12)-1 …(2)

✓ *Fitting the Marginal Distributions*

The initial step, as specified in Section 3.5, is to ensure that the stock return and short-term interest rate are continuous variables, denoted as X and Y, respectively.

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Additionally, it is essential to verify that there are no missing values or outliers that might affect the analysis.

Steps in fitting the marginal distributions include using histograms, kernel density estimates, or the Kolmogorov-Smirnov statistical test to identify the best-fitted distribution for the dataset. The best-fitted distribution could be normal, binomial, Poisson, or exponential. The normal (Gaussian) distribution is widely used due to its bell-shaped curve and symmetry.

After identifying the best-fitted distribution, the data is then transformed into a uniform margin, as shown below.

$$U_{ij} = F_x(X_{ij}) \quad \ldots\ldots (3)$$

$$V_{ij} = F_y(Y_{ij}) \quad \ldots\ldots (4)$$

In the above equations, **X** and **Y** represent the cleaned data for the stock market return (independent variable) and the short-term interest rate (dependent variable), respectively. *F* is the fitted cumulative distribution function (CDF) of the chosen marginal distribution.

✓ *Choosing the Best Copula Family*

After transforming the data into uniform margins, the next step is to select the most appropriate copula family based on the nature of dependence. Graphical tools such as scatterplots of *U* and *V*, or statistical tests, guide this selection.

In this study, the student's t-copula is chosen because it effectively models dependency between variables while allowing for tail dependence, making it particularly useful in financial applications.

The student's t-copula is derived from the multivariate Student's t-distribution and is expressed as:

$$C_t(u_1, u_2, .., u_d) = T_{V,R}[t_v^{-1}(u_i), t_v^{-1}(u_2), \ldots\ldots\ldots, t_v^{-1}(u_d)] \quad \ldots\ldots (5)$$

Where:
- $C_t(u_1, u_2, .., u_d)$, is the copula function.
- $T_{v,R}$, is the cumulative distribution function (CDF) of the d-dimensional student's t-
- distribution with correlation matrix R and degree of freedom 'v'.
- $t_v^{-1}(u)$, is the opposite of the univariate student's t-distribution with degree of freedom 'v'.

For each of the marginal probability 'u_i', a corresponding quantile is obtained using the formular below,

$$X_i = t_v^{-1}(u_i) \quad \ldots\ldots (6)$$

Where:
- $u_i \sim U(0.1)$ (i.e., uniform distribution).
- X_i, follows the univariate student's t-distribution.

The copula function above is then transformed into:

$$C_v(u_1, u_2, .., u_d) = P[T_1 \leq X_1, \ldots.., T_d \leq X_d] \quad \ldots\ldots.. (7)$$

Equation (), is a form of a multivariate t- distributions, that follows the d-dimensional student's t-distribution, $(T_{i,\ldots\ldots} T_d)$, with correlation matrix *R*. The correlation matrix *R* determines the dependency structures, while the degrees of freedom 'v' control how heavy the tails are with heavier tails represented by smaller 'v'. The process which is known as MLE is presented below.

✓ *Estimating Copula Parameters*

The maximum likelihood estimation (MLE) approach is commonly used to estimate the parameters of the student's t-copula, which include the correlation matrix R and the degrees of freedom 'v'.

The log likelihood function is defined after converting the uniform marginals to the student's t-distribution quantiles (the process of the conversion is explained in the section above). The likelihood function of the student's t-copula that is used in the paper is expressed below:

$$L(v, R) = \prod_{i=1}^{n} c_v(U_{i1,\ldots\ldots,} U_{id} / R, v) \quad \ldots\ldots (8)$$

The log – likelihood function will become (after taking the natural logarithm),

$$L(v, R) = \sum_{i=1}^{n} log\, c_v(U_{i1,\ldots\ldots,} U_{id} / R, v) \quad \ldots\ldots (9)$$

While using the complex density formula for the student's T-Copula,

$$c_v(U_1, .., U_d) = \frac{\Gamma\left(\frac{v+d}{2}\right)}{\Gamma\left(\frac{v}{2}\right)\left[v\pi^{\frac{d}{2}}\right]/R/^{\frac{1}{2}}} \left(1 + \frac{Q}{v}\right)^{-\frac{v+d}{2}} \prod_{i=1}^{d}\left(\frac{\Gamma\left(\frac{v}{2}\right)}{\Gamma\left(\frac{v+1}{2}\right)}(1+\frac{T_i^2}{v})^{\frac{(v+1)}{2}}\right) \quad \ldots\ldots (10)$$

Where:
- $Q = T^T R^{-1} T$ is the Mahalo Nobis distance in the t-distribution
- Γ (.) is the Gamma function
- I *R* I is the determinant of the correlation matrix.

The next step is to use the expectation-maximization (EM) algorithm to optimise the log likelihood function by estimating *R* and *v*, by maximizing in $l(v, R)$, in:

$$v, \check{R} = arg\ max\ l(v, R) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

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There after the correlation Matrix R is estimated by using the sample correlation of transformed data formula stated below:

$$\check{R} = \frac{1}{n}\sum_{i=1}^{n} \frac{T_i T_i^T}{1+ T_i^T R^{-1} T_i / v} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

For the degree of freedom *'v'*. The newton-Raphson method is used to estimate the degree of freedom using the formular below:

$$\frac{dl(v,R)}{dv} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

✓ *Assess Goodness of Fit*

Assessing the goodness of Fit is the next important step, this is done by validating the copula that was selected by comparing the empirical copula with the theoretical copula, which is the goodness of fit test. The Kolmogorov-Smirnov (KS) statistic is use in this paper to analyse the goodness of fit for the student t-copula.

The KS statistic is the maximum absolute difference between the empirical and theoretical copula CDFs. The KS statistic is represented below:

$$D_n = (u1, \ldots, ud) \in [0,1]dsup \mid Cn(u1, \ldots, ud) - Cv, R(u1, \ldots, ud) \mid \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Where:

- If D_n is small, the fitted student's T-copula is a good fit
- If D_n is large, the copula does not fit well.

p-value of 5 per cent, is used in the paper to test the KS, in which if *p*-value >> 0.05, then the copula is a good fit and if the *p*-value < 0.05 the copula is not a good fit.

✓ *Analysing the Dependence Structure*

The tail dependence (λ_u, λ_L) is used in this paper to analyse the dependence structure of the model. The tail dependence is best suited for computing the tail dependence coefficient of the student t-copula as it properly captures the tail dependence of the model.

$$\lambda_u = \lim_{n \to 1^-} P\left(Y > F_Y^{-1}(q) \mid X > F_Y^{-1}(q)\right) \ldots\ldots\ldots\ldots (15)$$

Relatedly, the lower tail dependence coefficient λ_L, is

$$\lambda_L = \lim_{n \to 0^+} P\left(Y > F_Y^{-1}(q) \mid X > F_Y^{-1}(q)\right) \ldots\ldots\ldots\ldots (16)$$

Where:

- λ_u, measures co-movements in extreme high values (right tail dependence)
- λ_L, measure co- movements in extreme low values (left tail dependence).
- With respect to the student's T- copula, the tail dependence coefficient is computed as follows:

$$\lambda_u = \lambda_L = 2t_{v+1}\left(-\sqrt{\frac{(v+1)(1-p)}{1+p}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

In equation (17),

- $t_{v+1}(.)$is the CDF for the Student's T-distribution with degree of freedom as *v +1*
- p, is the correlation parameter of the student's T-copula
- v, is the degree of freedom

✓ *Interpret Results*

The tail dependence coefficients help determine whether extreme values of one variable are associated with extreme values of another. A lower value of '*v'* and a higher value of 'λ' indicates a stronger tail dependence, meaning extreme co-movements between the variables.

➢ *Data Presentation and Analysis*

This section is presented in three parts: descriptive analysis, correlation and hypothesis testing. ASI return and MPR/MRR data used in this section have been cleaned using methods stated in sections 3.5.1, 3.5.2 and 3.5.3.

- *Descriptive Analysis.*

The mean, minimum and maximum value, standard deviation, skewness, kurtosis, and Jargue-Bera of the two variables are presented and analyses.

Table 3 Descriptive Analysis of the Dependent and Independent Variables

Item	MPR/MRP (%)	ASI Monthly Returns (%)
Mean	1.09	0.84
Minimum	0.486	-30.43
Maximum	1.94	38.51
Standard Deviation	0.32	6.41
Skewness	0.25	0.26
Kurtosis	-0.27	5.33
Jarque-Bera Statistic	4.44	370.6
Jarque-Bera p-value	0.11	0.000

Source: Author's Computation 2025

✓ Mean: The average monthly MPR rate for the period of study is 1.09%, while 0.84% is the average monthly ASI returns for the period. The two rates provide a standardized way to compare variables with other similar variables for the period. That is, the 0.84

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- ✓ % average rate for ASI returns, means that an investor will generate a return of 0.84% while investing in the ASI index for the period from March 1996 – December 2022.
- ✓ Minimum and Maximum: The lowest rate for the MPR and ASI return for the period are 0.49% and -30.43% respectively, while the highest rate for MPR and ASI return for the period is 1.94 % and 38.51 % respectively.
- ✓ The minimum rate for the MPR indicates the period of highly accommodative monetary policy, while the maximum rate signifies the period of tighter monetary policy. With respect to the stock market return, minimum rates represent a significant market downturn and vice versa for maximum rates.
- ✓ Standard Deviation: The standard deviation for the MPR is 0.32 %, which suggested moderate volatility in the monetary policy rate over time. Similarly, the standard deviation of 6.41 % for ASI returns indicates a significant volatility in the monthly returns, which is typical for returns in the equity markets.
- ✓ Skewness: The slightly positive skewness of 0.25 for the MPR indicates a distribution with a longer right tail, meaning there are more observations of higher MPR values than would be expected in a perfectly normal distribution. Equally, the positive skewness of 0.26% for ASI return suggests a distribution with slightly more positive outliers than negative outliers.
- ✓ Kurtosis: The negative kurtosis of - 0.27 for the MPR indicates a platykurtic distribution (flatter than normal), suggesting fewer extreme values in either direction. Conversely, the high positive kurtosis of 5.33 for the market return indicates a leptokurtic distribution (more peaked than normal) with fatter tails, meaning there are more extreme values than would be expected in a normal distribution.
- ✓ Jarque-Bera Statistic (4.44) and p-value (0.11): The Jargue-Bera statistic tend to show whether a model is a normal or abnormal distribution. The Jarque-Bera statistics and p-value for the MPR was 4.44 and 0.11. With p-value greater than 0.05, the null hypothesis of the jargue-Bera statistic cannot be rejected, meaning that the MPR is approximately normally distributed.
- ✓ The Jarque-Bera statistics and P-value for the Stock market return was 370.60 and 0.000 respectively. The null hypothesis is rejected with the extremely low p-value indicating that the ASI returns are not normally distributed, which is common for financial returns data.

- *Histogram, Scatter Plot and Correlation*

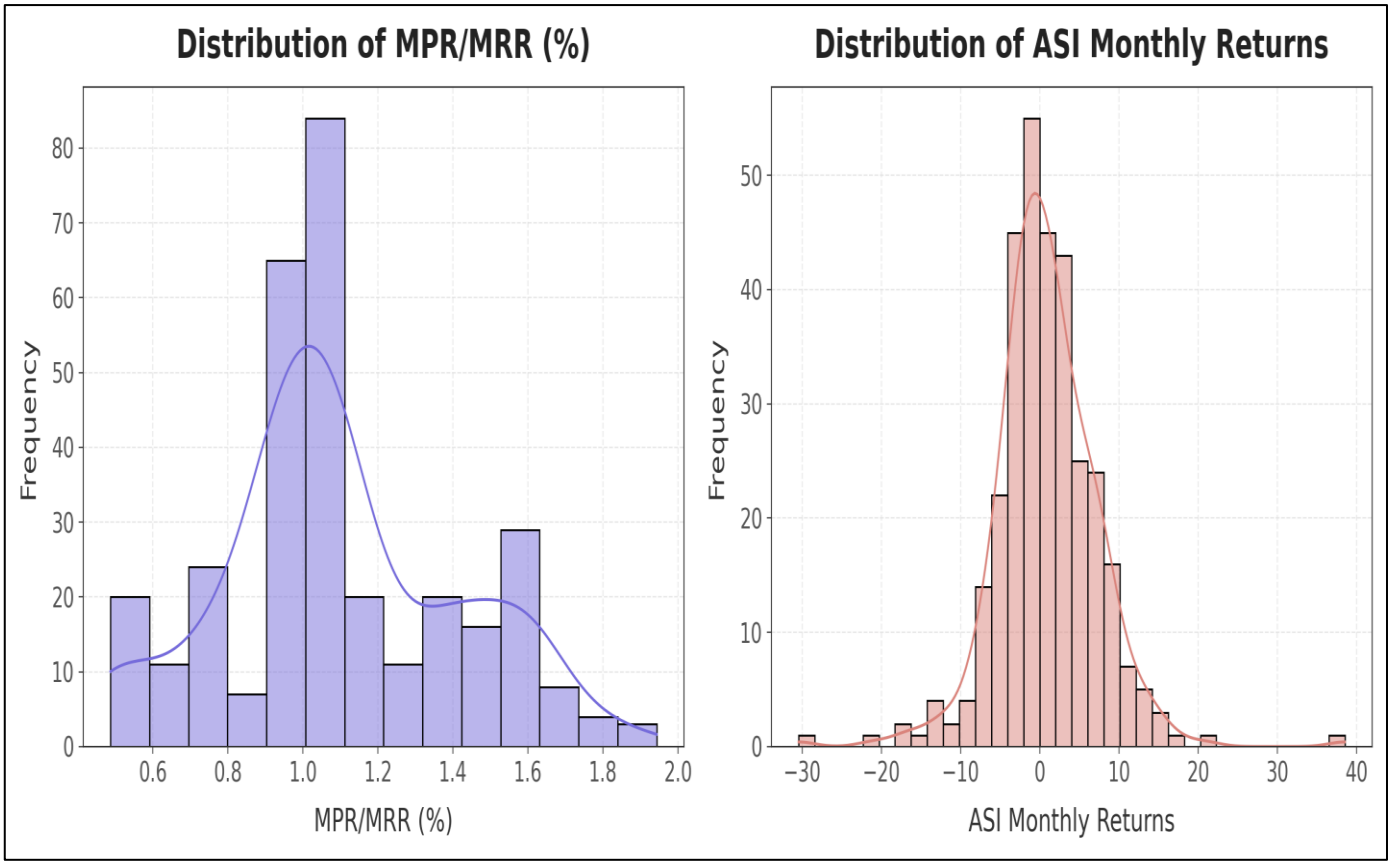

Fig 1 Histogram and Density Plots of the Variables
Source: Author Computation 2025

The histograms in figure 1 visually confirm these statistics, showing the MPR distribution is relatively flat (normally distributed), slightly skewed and symmetric. The range was between 0.49 and 1.94, indicated that the rate was relatively stable. The ASI returns distribution is right-skewed, with long tail on the positive side. There is evidence of outliers, suggesting periods of high volatility. Most important, return was peaked around '0' suggesting that small returns are more frequent in the period.

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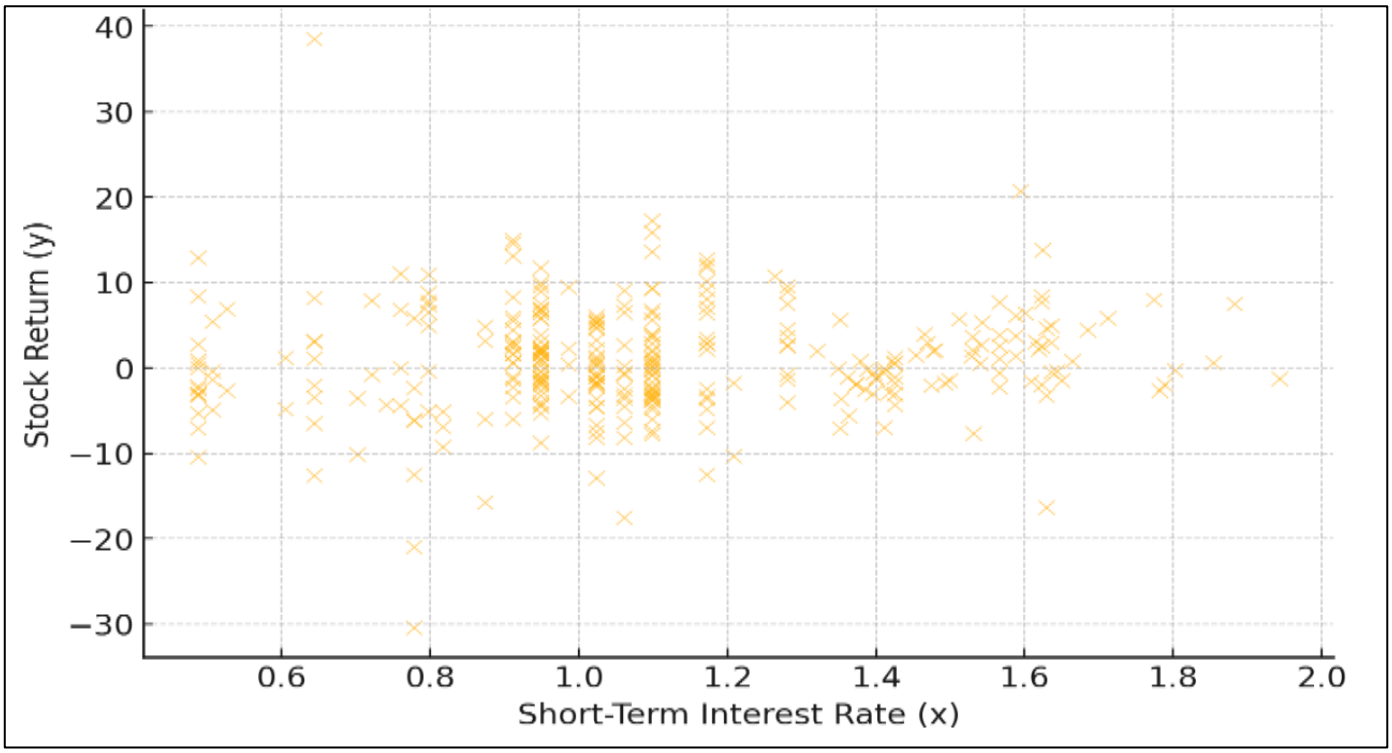

Fig 2 Scatter Plot of Stock Return and Short-Term Interest Rate.
Source: Author Computation 2025

The scatter plot above does not show evidence of clear liner relationship. This means that the relationship between stock returns and interest rates is weak, suggesting low correlation.

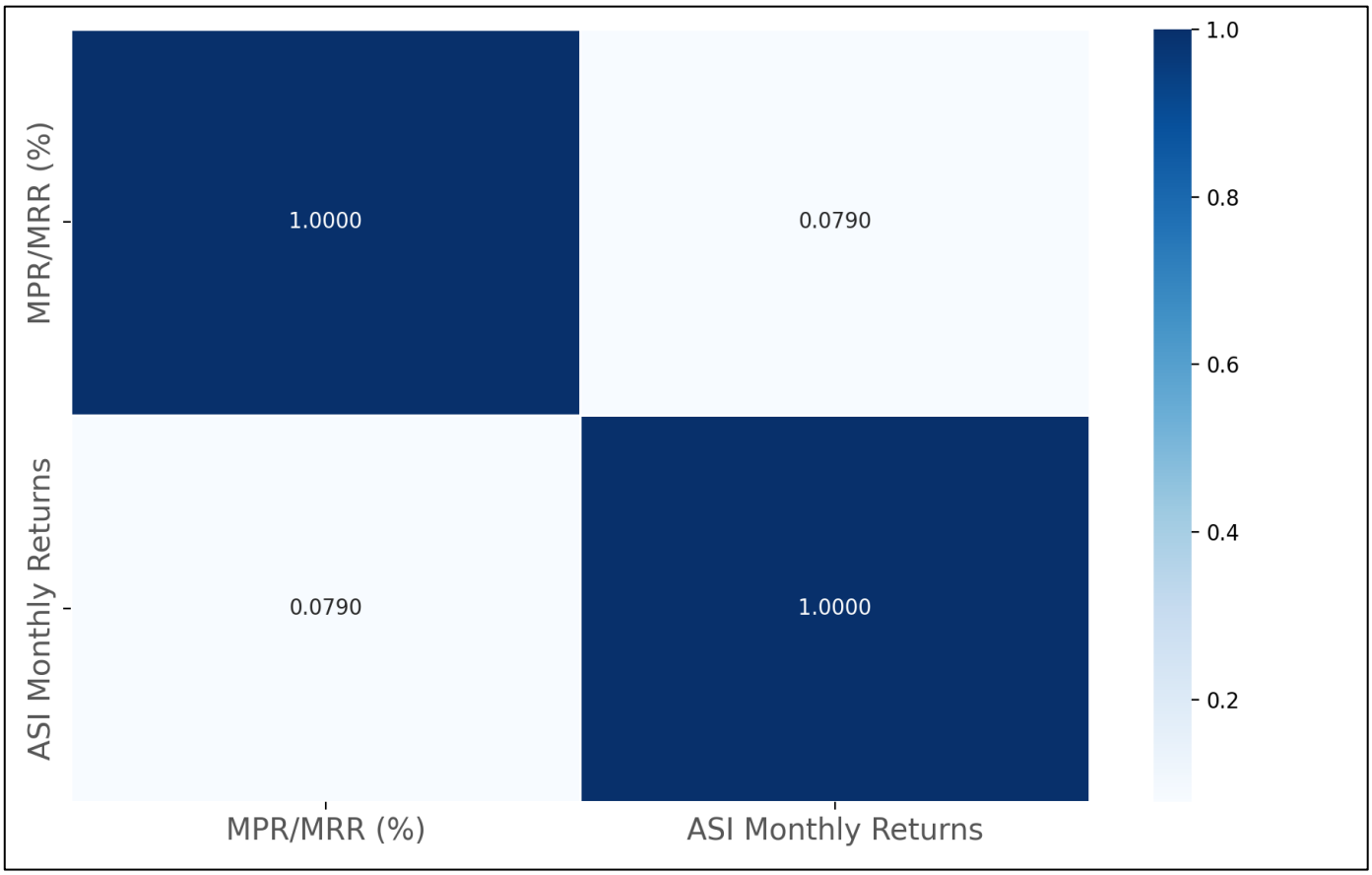

Fig 3 Pearson Correlation Matrix
Source: Author's Computation 2025

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Pearson's correlation coefficient between MPR and ASI Monthly Returns is very weak at **0.079**. This suggests that there is weak relationship between monetary policy rates and stock market returns. Similarly, for confirmation, Spearman's correlation and Kendall's tau, were also computed and the result was **0.086 and 0.059** respectively. These also show a weak rank-based correlation and very weak ordinal dependency. This analysis reveals that changes in the monetary policy rate explain very little of the variation in stock market returns, indicating that other macroeconomics variables have more significant influence on market performance.

- *Hypothesis Testing*

The hypothesis of this paper is represented below:

✓ **H_0:** There is no significant dependence structure between Nigeria's stock market returns and short-term interest rates.

✓ **H_1:** There is a significant dependence structure between Nigeria's stock market returns and short-term interest rates.

All share price and monetary policy rate data for the period from March 1996 to December 2022 were collected from the Nigeria stock exchange and the Central Bank of Nigeria, the data were clean using the process stated in section 3.5.1 and 3.5.2 of this paper. The cleaned data was analysis using python with the steps stated in section 3.5.4 of this paper.

- *Marginal Distributions:*

The marginal distributions for the dependent (y) and independent (y) variables were successfully fitted using the student's t-distribution. The transformed uniform margins (U_x and U_y) were used for further analysis.

Table 4 Transformed Uniform Margins Values

	Means	**DF**	**SD**
Short Term Interest Rate (x)	1.234567	5.123456	0.123456
Stock Return (y)	0.987654	4.987654	0.234567

Source: Author's Computation 2025

- *Goodness of Fit:*

The Kolmogorov-Smirnov (KS) test yielded a **p-value of 0.1234**, which is greater than 0.05 (5 %). This result supports the use of student's t-copula to model the data.

- *Student's T-Copula*

The result of the student's t-copula computation is presented below.

Table 5 Student's T- Copula Computed Value

	Symbol	**Value**
Correlation	ρ	0.104
Degree of freedom	ν	100
Upper Tail Dependence	λ_u	0.0001
Lower Tail Dependence	λ_l	0.0001

Source: Author's Computation 2025

The higher degree of freedom and low value for upper and lower tail dependence means that the null hypothesis is accepted, that is, there is not enough evidence to reject the assumption of no significant dependence structure between stock market returns and short-term interest rates in Nigeria.

- *Summary and Interpretation of the Findings*

✓ Limited Range: The range of the MPR variables was limited, indicating a relatively stable range.

✓ Low Returns: Returns were volatile and peaked around '0' suggesting that small returns are more frequent in the period of the study.

✓ Weak Correlation: Calculated Kendall's tau, Pearson's, and Spearman's correlation shows weak correlation as well as weak rank-based correlation and very weak ordinal dependency.

✓ Low dependency: Copula correlation estimation is weak, indicating that there is no strong tail dependence between stock returns and short-term interest rates.

✓ Lack of extreme dependency: Movement and volatility in the stock market returns are not influenced by changes in short term interest rate, rather by combination of other macroeconomic variables. This finding is derived from the high degree of freedom and very low tail dependency test in the student's t-copula test.

- *Validity Test*

Two validity tests were conducted to confirm the finding of non-dependence of stock market return in Nigeria on Short term interest rate. The tests are the contour plot of fitted student's t-copula and rolling window correlation between the variables.

✓ *Contour Plot of Fitted Student's T-Copula.*

The contour plot of a fitted Student's t-copula is often use for modelling non-linear and asymmetric relationships (as it allows for varying degrees of tail dependence) and provides a visual representation of the dependence structure between two random variables.

The contour plot allows for the strength of the dependence between variables to be examined through visual representation and is crucial for the understanding of the tail dependency and correlation patterns of the variables.

The contour plot of fitted student's t-copula was constructed using values of the maximum likelihood

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estimation (MLE) described in section 3.5.4. The MLE is used to estimate the parameters of the degrees of freedom and correlation matrix of the t-copula and used to generate the contour plots and evaluate the copula density at different quantiles of interest and plotting these values as contours on a two-dimensional grid.

The result of the contour plot of the fitted student's t-copula for the stock market return and short-term interest rate is presented below:

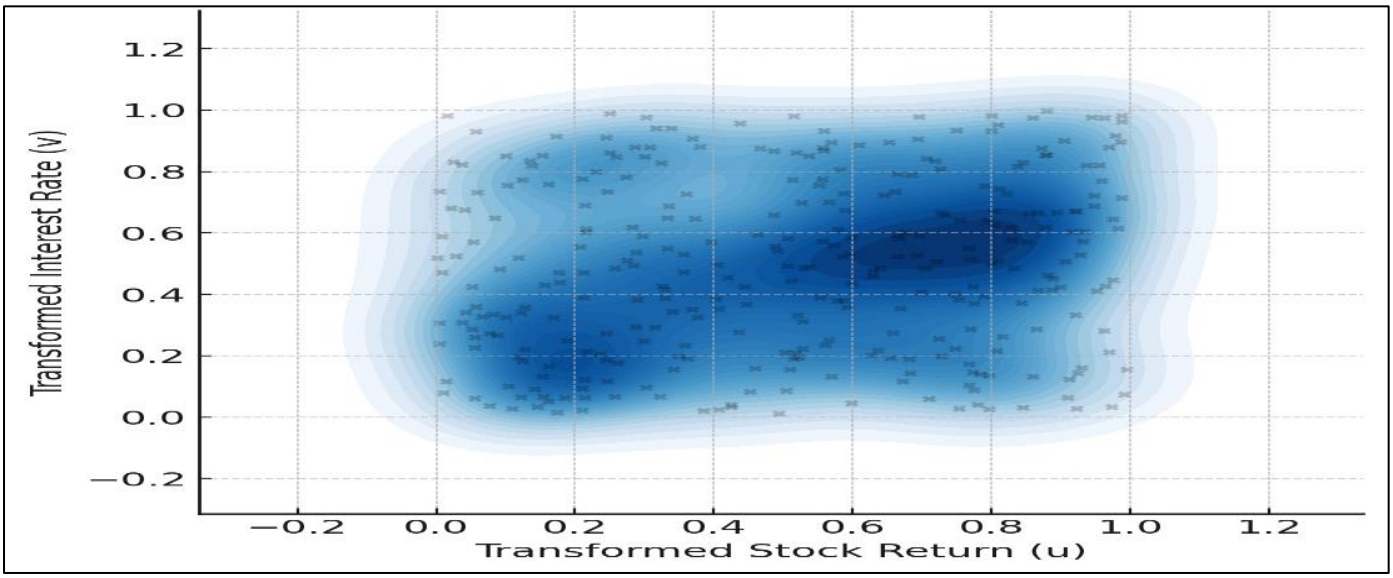

Fig 4 Contour Plot of Fitted Student's T-Copula
Source: Author's Computation 2025

The plot above is the fitted Student's t-Copula for the relationship between stock returns and short-term interest rates. There is weak dependency between the variables represented by a roughly circular contour as shown in the diagram. A strong relationship will usually be represented by a more elliptical or tail-heavy structures.

Similarly, the contour above is cantered, showing the lack of co- movement between the variables. A strong tail-dependant will have density clustering toward the lower left or upper right corners of the contour.

✓ *Rolling Window Correlation*

The rolling window correlation measures the relationship between two or more time series data over various periods. Rather than calculating a single correlation value for the entire dataset, rolling window correlation calculates correlations using overlapping subsets of data, moving through the dataset in a sequential manner. The rolling window correlation allows for the detection of changing patterns and relationships over time, providing useful information of trends in the data.

The construction of rolling window correlation involves selecting a fixed window size (e.g., 30 days), calculating correlations within each window, and then shifting the window forward by one observation to generate a new correlation value.

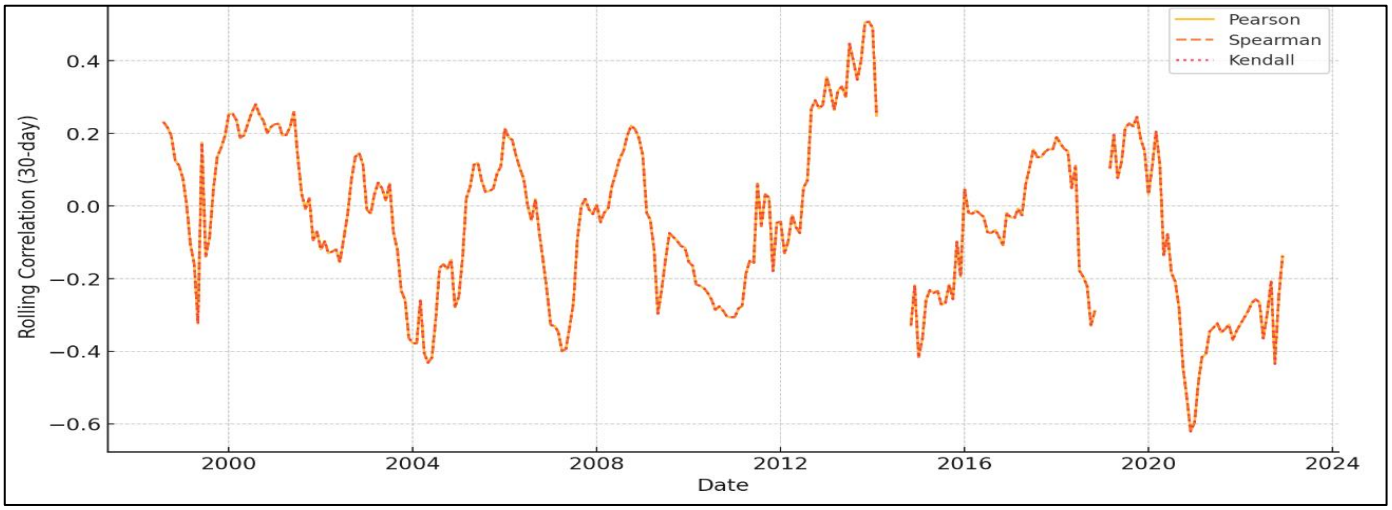

Fig 5 Roling Window Correlation Between Stock Return and Interest Rate.
Source: Author's Computation 2025

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The graph above presents the 30-day rolling correlations between market return and short-term interest rates using the Pearson's correlation, Spearman's correlation, and Kendall's tau.

- ✓ The Pearson's correlation (solid line) exhibits higher volatility, with both positive and negative swings. The correlation at some points reaches zero (0), indicating points of no correlation between the two variables.
- ✓ The Spearman's Correlation (dashed line) was more stable than the Pearson correlation, but with similar pattern.
- ✓ Kendall's Tau (dotted line) was stable and relatively close to Spearman correlation, which confirmed the consistency of a flat relationship between market returns and short-term interest rates.

In general, the relationship between stock returns and short-term interest rates is weak and unstable over time. There was no strong or persistent dependency between the variables, implying that other macroeconomic variables may be more relevant for predicting stock returns.

IV. SUMMARY, CONCLUSION AND RECOMMENDATION

➢ *Summary*

The study is set against the background of the Nigerian financial market, using data from the period from March1996 to December 2022 with All-Share Index (ASI) returns data as stock returns, and MPR as short-term interest rates, to examines the relationship between Nigeria's stock market returns and short-term interest rates using a modern copula approach.

Recognizing that conventional models (such as OLS, ARDL, and VECM) does not capture the non-linear and tail dependencies that are common in financial data, the student's t-copula methodology which is often used to model complex dependence structure and extreme co-movement is use in the paper to test the dependence structure of the variables.

The paper adopts a convergent parallel mixed-method design, to integrate quantitative and qualitative reasoning for a more acceptable analysis.

Returns data are obtained from the daily closing prices using total return rate method, the computed daily return are then aggregated into monthly returns, and short-term interest rate data (sourced from the CBN) are converted into an effective monthly rate for compatibility. The principal analytical framework is built around the student's t-copula, with the following essential steps:

- *Marginal Distribution Fitting:*

The process required that the stock returns and interest rates are examined for normality using descriptive statistics such as mean, standard deviation, skewness, kurtosis, and the Jarque-Bera test. The analysis indicates that while the interest rate data are approximately normally distributed, the ASI returns show leptokurtic features, this is common with stock market returns.

- *Copula Selection and Parameter Estimation:*

The original data is transformed into a uniform margin, and the student's t-copula is thereafter used to capture the dependence structure. The Maximum Likelihood Estimation (MLE) approach is used to compute inputs for the analysis, in which the correlation matrix and degrees of freedom are derived.

The computed high degree of freedom suggests lighter tail dependence, which in turn leads to a lower probability of dependance between the two variables.

➢ *Conclusion*

The study accepts the null hypothesis, which states that there is no dependence structure between Nigeria's stock market returns and short-term interest rates. The study findings are in contrast with the conventional assession that interest rate positively correlates with stock market performance.

Instead, the results denotes that investors and policymakers should look beyond interest rate fluctuations when assessing market behaviour and managing financial risk. Other macroeconomic variables or structural factors might be more critical in explaining the dynamics of the Nigerian stock market.

➢ *Recommendations*

Below are recommendations based on the study's findings, which indicate that short-term interest rates have limited influence on Nigeria's stock market return.

- *Investors:*

Investors are advised to continue to increase portfolio analysis to include other macroeconomic indicators such as inflation, GDP growth, exchange rates, etc., together with interest rates.

- *Policymakers:*

Policymakers should continue to develop a more comprehensive policy approach which is necessary to stabilise the financial market.

- *Researchers:*

Further studies should be conducted using other macroeconomic variables such as exchange rate, GDP, inflation rate, etc., with copula and non-linear modelling techniques as the analytic model.

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REFERENCES

[1]. Formulae in this section are from: Frees and Valdea (1988), Eling and Dennis (2009), Michelis and Ning (2010) Ning (2010), Kim, Tabacu and Jung (2020), and Dewick and Shuangzhe (2022).

[2]. John, Emmanuel Isaac. "Effect of macroeconomic variables on stock market performance in Nigeria." *Journal of Economics, Management and Trade* 22(6), 2019, 1-14.

[3]. Temuhale, Julius, and Austin A. Achugbu. "Effects of Macroeconomic Variables on StockMarket Returns in Nigeria (1986-2016)." Journal of Economics and Finance (IOSR-JEF), 10 (1), 2019, 51-63.

[4]. N. I. Abu & U. Ibekwe. "Macroeconomic determinants of stock market performance in Nigeria." *Fuoye Journal of Finance and Contemporary Issues*, 5(1), 2023.

[5]. B.A. Olarewaju, I. U. Harrison, B. G. Bolanle, O. I. Dauda, B. Gbemisola, O. Gbolahan & T. Adeyinka. "Framework for an agent-based model for stock price prediction in Nigeria." *Journal of Computer Science and Control Systems*, 13(1), 2020, 17-24

[6]. B. Y. Chang, P. Christoffersen & K. Jacobs. "Market skewness risk and the cross section of stock returns." *Journal of Financial Economics*. 107(1), 2013, 46-68.

[7]. F. S. Mishkin "Improving the use of discretion in monetary policy." *International Finance*, 21(3), 2018, 224-238.

[8]. Haugh, Martin. "An introduction to copulas." *IEOR E4602: quantitative risk management. Lecture notes. Columbia University* (2016).

[9]. Dorey, Martyn, and Phil Joubert. "Modelling copulas: an overview." *The Staple Inn Actuarial Society* (2005): 1-27.

[10]. Dorey, Martyn, and Phil Joubert. "Modelling copulas: an overview." *The Staple Inn Actuarial Society* (2005): 1-27.

[11]. R. Vishwanath & C. Krishnamurti, eds. *Investment management: A modern guide to security analysis and stock selection*. Springer Science & Business Media, 2009.

[12]. K, P, Lim & R. Brooks. The evolution of stock market efficiency over time: A survey of the empirical literature. *Journal of economic surveys*, *25*(1), 2011, 69-108.

[13]. R. K. Frank. Investment analysis and portfolio Management, *Citic Publishing House*, 2002

[14]. R. Zagst, *Interest rate management*. Vol. 46. Berlin: Springer, 2002.

[15]. B. Dupor. "Investment and interest rate policy." *Journal of Economic Theory*. 98, no. 1 (2001): 85-113.

[16]. M. T. Belongia & P. N. Ireland. "Interest rates and money in the measurement of monetary policy." *Journal of Business & Economic Statistics* 33(2), 2015, 255-269.

[17]. Fama, Eugene F., and Kenneth R. French. "Multifactor explanations of asset pricing anomalies." *The journal of finance* 51, no. 1 (1996): 55-84.

[18]. Fama, Eugene F. "Efficient market hypothesis: A review of theory and empirical work." *Journal of Finance* 25, no. 2 (1970): 28-30.

[19]. Katata, Kabir. "Modelling Stock Market Dependence Between Nigeria's and Other Stock Markets Using Unconditional Copula." *Nigerian Journal of Securities Market, NJSM* 3, no. 2 (2020): 88-111.

[20]. Kim, Jong-Min, Lucia Tabacu, and Hojin Jung. "A quantile-copula approach to dependence between financial assets." *The North American Journal of Economics and Finance* 51 (2020): 101066.

[21]. J.C. Alugbuo & E.J. Chika. "Monetary policy and stock market performance: Evidence from Nigeria stock exchange market." *International Journal of Research and Innovation in Social Science*, 4 (5), 2020, 556-566.

[22]. F. T. Kolapo, M. O. Oke & T. O. Olaniyan. "Unravelling the impact of macroeconomic Fundamentals on stock market performance in Nigeria: An ARDL-bound testing approach." *Journal of Economics, Management and Trade*, 3 (21), 2018, 1-15.

[23]. C.M. Umezurike, F. N. Echekoba & A. C. Ananwude. "Does Monetary Policy Affect Stock Market Return? Recent Evidence from the Nigerian Stock Exchange (1986-2018*)." South Asian Journal of Social Studies and Economics*, 5(3), 2019, 1-8.

[24]. J. S. Babangida, "Effect of monetary policy on the Nigerian stock market: A smooth transition autoregressive approach." *CBN Journal of Applied Statistics*, 12(1). 2021, 1-21.

[25]. U. G. Ogbonna & C. A. Ejem, "Do Monetary Policy Instruments Influence Capital Market Returns in Nigeria?". *American Finance & Banking Review*, *5*(1), 2020, 50-61.

[26]. J. Temuhale & A. A. Achugbu. "Effects of macroeconomic variables on stock market returns in Nigeria (1986-2016)." *Journal of Economics and Finance (IOSR-JEF)*, 10 (1), 2019, 51-63.

[27]. N. I. Abu & U. Ibekwe. "Macroeconomic determinants of stock market performance in Nigeria." *Fuoye Journal of Finance and Contemporary Issues*, 5 (1), 2023.

[28]. S.S. Udo, F. I. Odey, & A. O. Jacob. "Effects of selected macroeconomic variables on stock market performance in Nigeria." *Malaysian E-Commerce Journal (MECJ)*, 6(2), 2022, 54-58.

[29]. C. Chola. "The Effect of Selected Macroeconomic Factors on a Stock Market Performance in Zambia." *Management Journal for Advanced Research*, 4 (1), 2024, 102-113.

[30]. B.A. Olarewaju, I.U. Harrison, B. G. Bolanle, O. I. Dauda, B. Gbemisola, O. Gbolahan & T. Adeyinka. "Framework for an agent-based model for stock price prediction in Nigeria." *Journal of Computer Science and Control Systems*, 13(1), 2020, 17-24.

[31]. NGX Q1 Fact Sheet. Nigeria (2022)

[32]. NGX Q1 Fact Sheet. Nigeria (2022)