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Use of a generalized gamma additive model to determine the effect of monetary policy on the Nigerian stock market

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Abstract

This study looked at how monetary policy affected the Nigerian stock market's performance from 2006 to 2020 using Generalized Additive Model for Location, Scale, and Shape (GAMLSS). The method expands the capabilities of linear, generalized linear and additive models. The All-Share Index was used to gauge the performance of the Nigerian stock market. Money supply, interest rate, exchange rate, and inflation rate were used to gauge monetary policy, which served as the explanatory variable. In order to choose the best fitted model, some selected GAMLSS family distributions in the positive real line, including the Generalized gamma, Gumbel, Weibull, and Log normal distributions, were fitted to the data. The Generalized Gamma (GG) distribution best fits the response variable, according to the AIC and BIC results. In order to ascertain how monetary policy affected the Nigerian Stock Market, GG in GAMLSS was employed. The study's conclusions demonstrate that whereas other variables have negative associations with the All-Share Index, the money supply has a positive link with it. The Nigerian Stock Market All-Share Index is significantly impacted by each of the explanatory variables.

Keywords: all-share index; GAMLSS; generalized gamma distribution; monetary policy; stock market

1 Introduction

The stock market is viewed as the engine of economic growth since it is essential for capital allocation and mobilization to promote economic growth. A sophisticated stock market makes it easier to sterilize significant inflows of capital (Turner, 2002). It is a type of investment that does not necessitate the investor's personal presence or managerial abilities. The rise of the stock market encourages financial integration and development, which boosts economic growth by increasing capital allocation efficiency and facilitating better risk sharing (Laeven, 2014). According to Mishkin (2007), a functioning financial market is essential for fostering long-term economic progress, and underperforming fiscal markets are one of the reasons that many nations around the world continue to live in abject poverty.

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Financial and monetary economists in Nigeria have been conducting extensive study on the connection between monetary policy and stock market performance since the country's economy was deregulated. Using an error correction model, Maku and Atanda (2010) investigated the factors that affect stock market performance in Nigeria. The results of the empirical investigation demonstrated that macroeconomic factors have effects on the long-term performance of the Nigerian capital market. Okpara (2010) used the Two Stage Least Squares Method to study the influence of monetary policy on the returns on the Nigerian stock market.

Asaolu and Ogunmuyiwa (2011) looked into how macroeconomic factors affected the average share price (ASP) and further explored if shifts in these factors could account for changes in stock prices in Nigeria. Using the OLS, Osisanwo and Atanda (2012) investigated the factors influencing stock market returns in Nigeria. The results showed that the primary factors of stock returns in Nigeria are interest rate, money supply, levels of prior stock returns, and exchange rate. Using the Vector Error Correction Model (VECM), Osamwonyi and Evbayiro-Osagie (2012) examined the association between macroeconomic factors and the Nigerian capital market index. Macroeconomic factors have been discovered to affect the Nigerian stock market index. Nwakoby and Alajekwu (2016) employed price-based monetary policies to look at how monetary policies affected the performance of the Nigerian stock market using three different approaches.

Using the auto-regressive distributed lag (ARDL) model, Anaele and Umeora (2019) investigated the association between monetary policy and the Nigerian capital market. Using the OLS multiple regression technique, Akanbi (2021) investigated the effect of monetary policies on the performance of the stock market in Nigeria.

The majority of the methods used in the literature would be unable to deal with data heterogeneity and model skewness and kurtosis. Thus, using the GAMLSS, this study investigates the effect of the CBN's price-based monetary policy instruments' anchor on stock market performance indicators. The GAMLSS model is a semi-parametric regression model. which can handle data heterogeneity and model skewness and kurtosis. It can also be used to reduce model overdispersion.

2 Materials and methods

2.1 Research design
The data for this study came from past records of data on the All-Share Index, money supply, interest rate, exchange rate, and inflation rate in the Nigerian Stock Market Statistical Bulletin from 2006 to 2020, a period of 15 years. The performance of the Nigerian stock market (proxy as All-share Index) was used as the dependent variable. Monetary policies functioned as explanatory variables. The money supply (MS), yearly interest rate (INT), yearly inflation rate (INF), and exchange rate (EXCH) were used as proxies for monetary policy. The GAMLSS regression model was used to establish a causal effect of independent variables on the dependent variable. The R programming language was used for all analyses.

2.2 Method of data analysis
The LM, GLM, and GAM can all be thought of as extensions of GAMLSS. GAMLSS have two key characteristics. It was predicated that the distribution might be any parametric distribution and that all of its constituent parts—not just its location—may be modeled as smooth or linear functions of the explanatory factors. As a result, the response variable's distribution's position, size, and shape are all subject to vary in response to explanatory variables (Stasinopoulo *et al.*, 2018). GAMLSS are models of the semi-parametric regression variety.

Let $y^T = (y_1, y_2, \dots, y_n)$ be the response variable of length n. Let $g_k(.)$ be a known monotonic link function connecting the distribution parameters to the explanatory variables for $k = 1, 2, 3, 4$.

$$g_k(\theta_k) = \eta_k = X_k\beta_k + \sum_{j=1}^{J_k} Z_{jk}\gamma_{jk} \tag{1}$$

$$g_1(\mu) = \eta_1 = X_1\beta_1 + \sum_{j=1}^{J_1} Z_{j1}\gamma_{j1} \tag{2}$$

$$g_2(\sigma) = \eta_2 = X_2\beta_2 + \sum_{j=1}^{J_2} Z_{j2}\gamma_{j2} \tag{3}$$

$$g_3(v) = \eta_3 = X_3\beta_3 + \sum_{j=1}^{j_3} Z_{j3}\gamma_3, \tag{4}$$

$$g_4(\tau) = \eta_4 = X_4\beta_4 + \sum_{j=1}^{j_4} Z_{j4}\gamma_{j4}, \tag{5}$$

where $\mu, \sigma, v\ \tau$ and η_k are vectors of length n, $\beta_k^T = \left(\beta_{1k}, \beta_{2k}, \dots, \beta_{J'_k k}\right)$ is a parameter vector (Rigby and Stasinopoulos, 2005).

Each distribution parameter can be modelled as a linear function of explanatory variables and/or as a linear function of stochastic variables using the model in (1). In GAMLSS implementation in R packages, there are numerous distributions and additive terms. This study would take into account the generalized gamma, Gumbel, Weibull, and Log normal distributions.

2.3 Model selection criterion

The Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC) criterion were used in this study to select the best model in GAMLSS. Let k denote the number of parameters, n the number of observations in the model and $\hat{L}$ the maximum value of the model's likelihood function.

$$AIC = 2k - 2ln(\hat{L}), \tag{6}$$

$$BIC = kln(n) - 2ln(\hat{L}). \tag{7}$$

The preferred model for a data, out of a set of candidate models, is the one with the lowest AIC and BIC values.

3 Results and discussion

Table 1 displays the minimum, first quartile, median, mean, third quartile, maximum, and skewness values for the ASI, MS, INF, INT and EXCH. ASI, MS, INF, and EXCH are all positively skewed, whereas INT is negatively skewed.

Table 1: Descriptive statistics of variables

	MIN	Q₁	MEDIAN	MEAN	Q₃	MAX	SKEWNESS
ASI	19851.9	25281.9	29692.5	32157.8	37150.9	65652.4	1.1831
MS	2227472.8	9802494.7	7718841.4	18622470	8081470.1	38627352.2	0.2594
INT	11.3	16.0	16.7	16.6	17.2	19.66	-1.0919
INF	5.4	8.8	11.6	11.4	13.2	17.9	0.0997
EXCH	108.3	147.7	155.3	200.0	305.2	379.5	0.7847

Figure 1 presents the correlation matrix of pairs of variables used in this study while table 2 gives the p-values of the correlation matrix. All the variables are negatively correlated All-share index and their p-values are significant.
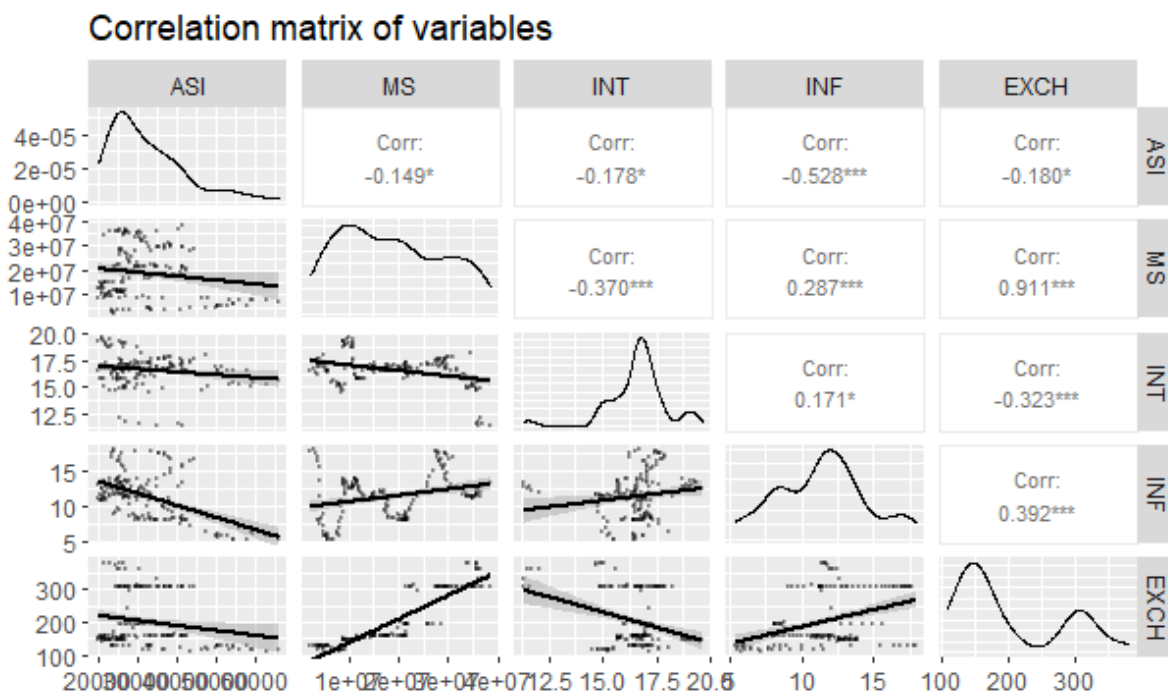

Figure 1: Correlation Matrix of pairs of variables

Table 2: P-values of correlation matrix

	ASI	MS	INT	INF	EXCH
ASI		0.0462	0.0168	0.0000	0.0154
MS	0.0462		0.0000	0.0000	0.0000
INT	0.0168	0.0000		0.0214	0.0000
INF	0.0000	0.0000	0.0214		0.0000
EXCH	0.0154	0.0000	0.0000	0.0000	

We investigate the distribution that corresponds to the response variable. Figure 2 depicts the four most common and appropriate distributions for the response variable. Generalized gamma (GG), Gumbel (GU), Log-normal (LOGNO), and Weibull (WEI) distributions are fitted to the response variable. The generalized gamma distribution has the lowest AIC and BIC and is considered the best fit to the response variable. As a result, the Generalized gamma additive model is used to simulate the impact of monetary policy on the Nigerian stock market.
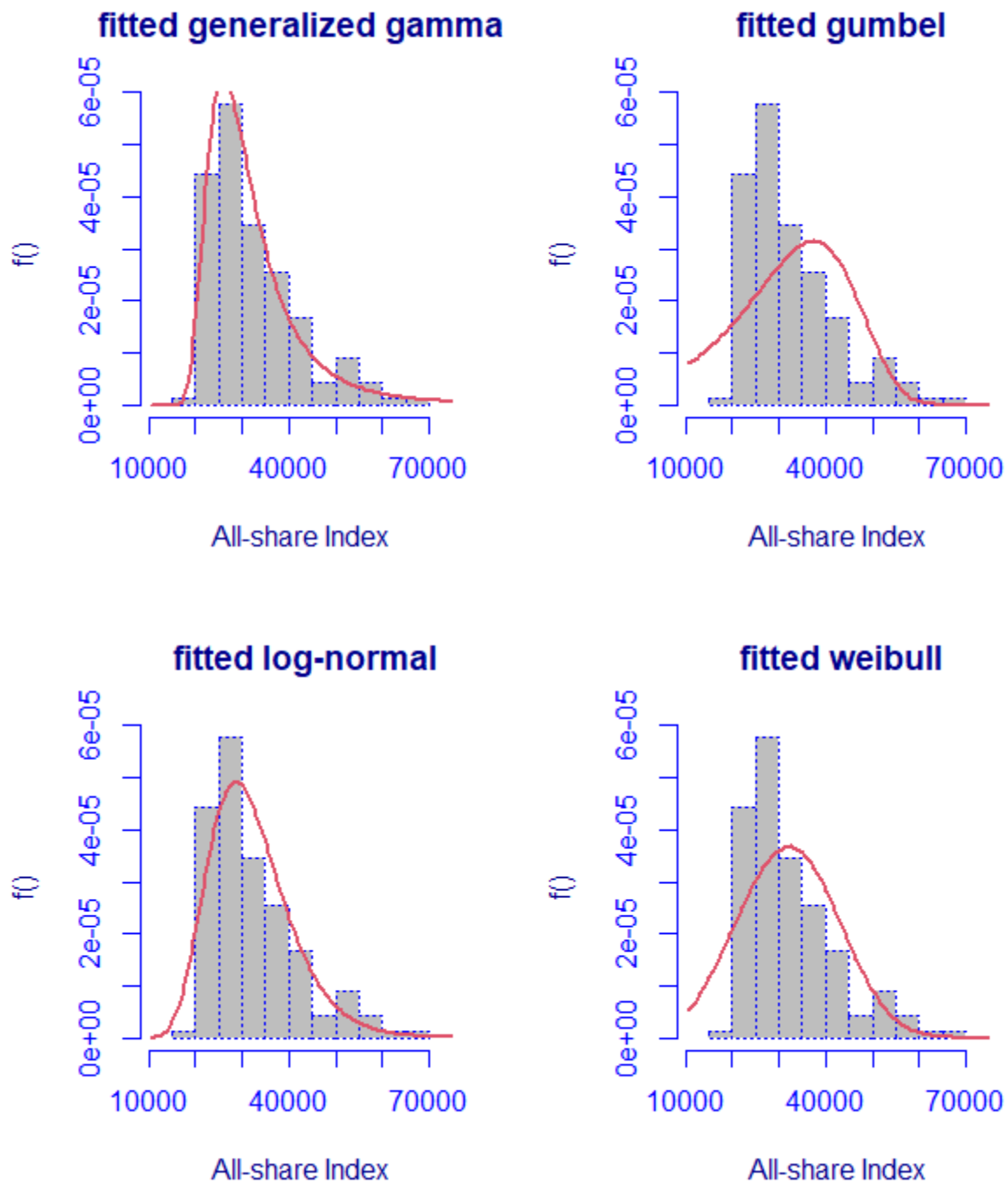
Figure 2: All-share Index and fitted Generalized gamma, Gumbel, Log-normal and Weibull distributions

Table 3: AIC and BIC of some selected distributions

DISTRIBUTION	GG	GU	LOGNO	WEI
AIC	3753.501	3897.999	3768.916	3820.882
BIC	3763.079	3904.385	3775.302	3827.268

We must keep in mind that GG has three distribution parameters. In GAMLSS, model that comprises the GG distribution, smoothing ps() with df = 3 was fitted, scale model modeled MS and shape (v) model modeled constant (Table 4). MS has a positive impact on the ASI, whereas INT, INF, and EXCH have a negative impact. All of these variables have significant effects. The model's R^2 is 0.6808, indicating that the explanatory variables could only explain approximately 68 percent of the variation in the response variable.

Table 4: Estimate and p-value of generalized gamma additive model for linear scale and shape (RS method)

μ LINK FUNCTION: LOG

	Estimate	P-value	Status
INTERCEPT	11.57	2×10^{-16}	Significant
PS(MS, DF = 3)	8.626×10^{-9}	1.08×10^{-6}	Significant
INT	-3.598×10^{-2}	5.22×10^{-7}	Significant
INF	-5.261×10^{-2}	2×10^{-16}	Significant
EXCH	-1.373×10^{-3}	1.74×10^{-7}	Significant

σ LINK FUNCTION: LOG

	Estimate	P-value	Status
INTERCEPT	-2.211	2×10^{-16}	Significant
PB(MS)	1.426×10^{-8}	0.00508	Significant

v LINK FUNCTION: IDENTITY

	Estimate	P-value	Status
INTERCEPT	-2.0175	0.000543	Significant

Thus, the best fitted model can be written in the form:
$\log(\mu) = 11.57 + (8.626 \times 10^{-9})\text{ps(MS, df = 3)} + (-3.598 \times 10^{-2})\text{ INT} + (-5.261 \times 10^{-2})\text{ INF} + (-1.373 \times 10^{-3})\text{EXCH}$

$\log(\sigma) = -2.211 + (1.426 \times 10^{-8})\text{ pb(MS)}$

$v = -2.0175$

4   Conclusion

GAMLSS was used in this study to investigate the effect of monetary policies on stock market activity in Nigeria. AIC and BIC were used to select the model that best fit the response variable from Generalized Gamma, Gumbel, Weibull, and Log-normal. The best model was determined to be Generalized Gamma with the lowest AIC and BIC. As a result, the data was modeled using a

generalized gamma additive model. MS, INT, INF, and EXCH could only explain 68 percent of the variation in Nigeria stock exchange market performance, according to the findings. A rise in the MS and a fall in the INT, INF, and EXCH would improve the performance of the Nigerian stock exchange. As a result, monetary policies have a substantial influence on the performance of the Nigerian stock market. In order to keep the Nigerian stock market appealing to investors, the monetary authorities should implement favorable monetary policies.

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