


PREDICTABILITY OF GARCH-TYPE MODELS IN ESTIMATING STOCK RETURNS VOLATILITY. EVIDENCE FROM KENYA

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ARTICLE INFO	ABSTRACT
<p>Article history:</p> <p>Received 15 August 2023</p> <p>Accepted 13 November 2023</p>	<p>Purpose: The aim of this paper was to evaluate which of the seven GARCH-type models, namely sGARCH, IGARCH, EGARCH, TGARCH, GJRGARCH, APARCH, and CGARCH, was suitable for predicting the Nairobi Securities Exchange-listed firms' volatility.</p>
<p>Keywords:</p> <p>Volatility; GARCH-type; Nairobi Securities Exchange; Prices; Returns.</p>	<p>Theoretical framework: The Efficient Market Hypothesis is crucial in predicting market value of stocks. Therefore, this study employed the efficient market hypothesis to the the predictability of the stocks returns volatility.</p>
	<p>Design/Methodology/Approach: In this study, we used census approach to collect data from 49 Nairobi Securities Exchange listed firms. The data was collected from 1st January 2011 to 31st December 2020. TO evaluate the volatility, we used the GARCH-type models.</p>
	<p>Findings: The study found that the APARCH model as the best suitable for forecasting the volatility of Nairobi Securities Exchange-listed firms.</p>
	<p>Research, Practical & Social implications: We propose the the APARCH model as the best suitable model for predicting volatility of stock returns. The findings can be used by investors in making judicious financial decisions. For acedmic purpose, the findings are essential in supporting new knowledge of which model is best fit in predicting the NSE stocks returns volatility.</p>
	<p>Original/ Value: The study contributes to the literature on the best suitable model in predicting the volatility of the stocks returns.</p>
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PREVISIBILIDADE DE MODELOS DO TIPO GARCH NA ESTIMATIVA DA VOLATILIDADE DOS RETORNOS DE AÇÕES. EVIDÊNCIAS DO QUÊNIA

RESUMO

Objetivo: O objetivo deste artigo foi avaliar qual dos sete modelos do tipo GARCH, nomeadamente sGARCH, IGARCH, EGARCH, TGARCH, GJRGARCH, APARCH e CGARCH, era adequado para prever a volatilidade das empresas listadas na Bolsa de Valores de Nairobi.

Enquadramento teórico: A Hipótese do Mercado Eficiente é crucial na previsão do valor de mercado das ações. Portanto, este estudo empregou a hipótese de mercado eficiente para a previsibilidade da volatilidade dos retornos das ações.

Desenho/Methodologia/Abordagem: Neste estudo, utilizámos a abordagem do censo para recolher dados de 49 empresas cotadas na Bolsa de Valores de Nairobi. Os dados foram recolhidos de 1 de janeiro de 2011 a 31 de dezembro de 2020. Para avaliar a volatilidade foram utilizados modelos do tipo GARCH.

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Constatações: O estudo concluiu que o modelo APARCH é o mais adequado para prever a volatilidade das empresas cotadas na Bolsa de Valores de Nairobi.

Implicações de pesquisa, Práticas e Sociais: Propomos o modelo APARCH como o modelo mais adequado para prever a volatilidade dos retornos das ações. As descobertas podem ser usadas pelos investidores na tomada de decisões financeiras criteriosas. Para fins acadêmicos, as descobertas são essenciais para apoiar novos conhecimentos sobre qual modelo é mais adequado para prever a volatilidade dos retornos das ações da NSE.

Original/ Valor: O estudo contribui para a literatura sobre o modelo mais adequado na previsão da volatilidade dos retornos das ações.

Palavras-chave: Volatilidade, tipo GARCH, Bolsa de Valores de Nairobi, Preços, Devoluções.

PREVISIBILIDAD DE LOS MODELOS TIPO GARCH EN LA ESTIMACIÓN DE LA VOLATILIDAD DE LOS RENDIMIENTOS DE LAS ACCIONES. EVIDENCIA DE KENIA

RESUMEN

Propósito: El objetivo de este artículo fue evaluar cuál de los siete modelos de tipo GARCH, a saber, sGARCH, IGARCH, EGARCH, TGARCH, GJRGARCH, APARCH y CGARCH, era adecuado para predecir la volatilidad de las empresas que cotizan en la Bolsa de Valores de Nairobi.

Marco teórico: la hipótesis del mercado eficiente es crucial para predecir el valor de mercado de las acciones. Por lo tanto, este estudio empleó la hipótesis del mercado eficiente para la previsibilidad de la volatilidad de los rendimientos de las acciones.

Diseño/ Metodología/ Enfoque: En este estudio, utilizamos un enfoque censal para recopilar datos de 49 empresas que cotizan en la Bolsa de Valores de Nairobi. Los datos se recopilaron desde el 1 de enero de 2011 hasta el 31 de diciembre de 2020. PARA evaluar la volatilidad utilizamos modelos tipo GARCH.

Hallazgos: El estudio encontró que el modelo APARCH es el más adecuado para pronosticar la volatilidad de las empresas que cotizan en la Bolsa de Valores de Nairobi.

Implicaciones de investigación, Prácticas y Sociales: Proponemos el modelo APARCH como el modelo más adecuado para predecir la volatilidad de los rendimientos de las acciones. Los inversores pueden utilizar los resultados para tomar decisiones financieras acertadas. Para fines académicos, los hallazgos son esenciales para respaldar nuevos conocimientos sobre qué modelo se adapta mejor a la predicción de la volatilidad de los rendimientos de las acciones del NSE.

Original/valor: El estudio contribuye a la literatura sobre el modelo más adecuado para predecir la volatilidad de los rendimientos de las acciones.

Palabras clave: Volatilidad, tipo GARCH, Bolsa de Valores de Nairobi, Precios, Devoluciones.

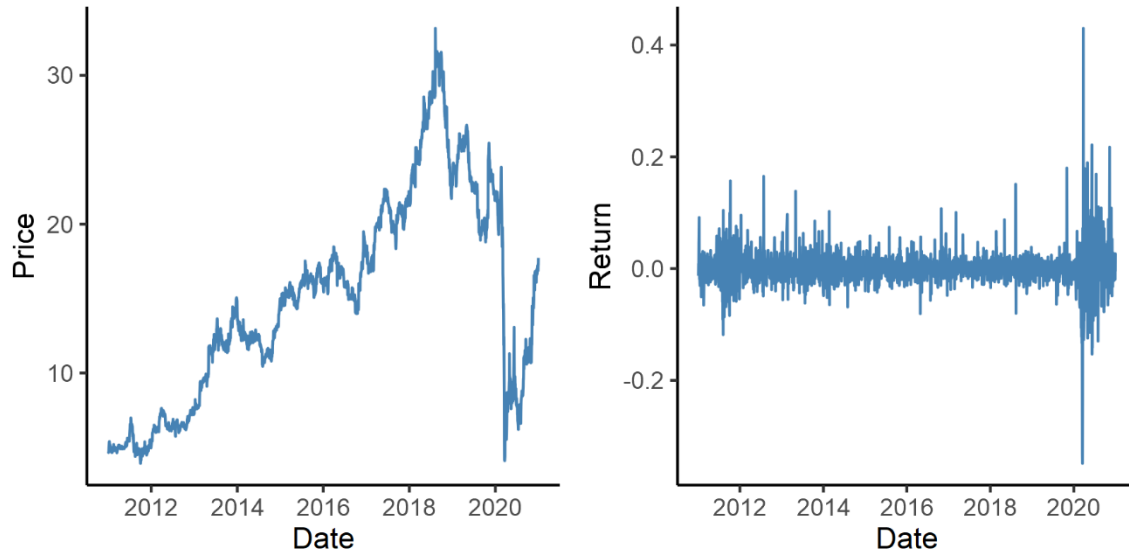
INTRODUCTION

The analysis of companies listed in the Nairobi Securities Exchange (NSE) interests financial experts, researchers, and investors. Given that NSE is an important stock market in Africa (Nairobi Securities Exchange, 2023), the performance of its listed firms is of broad interest. Investors must understand the stock market's volatility to make investment decisions and manage risks. Trading in stock markets is riskier than in the cash markets (Guo, 2022). Therefore, developing risk assessment approaches is accentuated for the NSE-listed firms.

The fluctuations in NSE prices (Figure 1) result in high volatility (Figure 2). Investors use stock market evaluations to purchase shares in a company for future profit gains. Stock market investments are highly risky due to stock returns being highly volatile. Investors depend on the volatility assessment to invest in the stock markets (Merkle & Weber, 2014; Galoyan & Hovsepian, 2023). Optimistic investors take advantage of the volatility increases, and markets

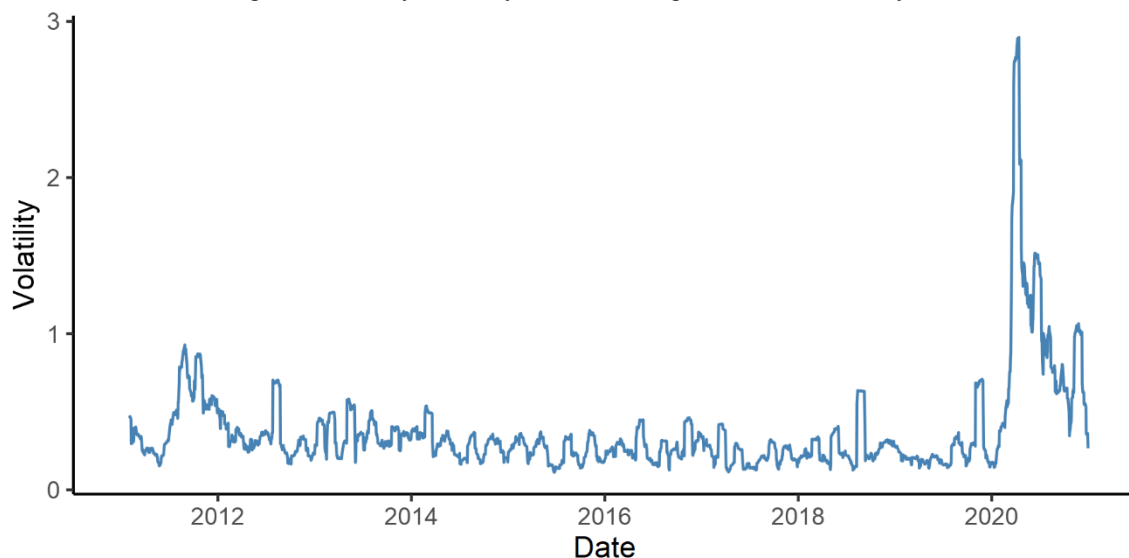
panic to hedge themselves against severe losses. However, higher volatility coupled with bear markets stresses investors as they experience portfolios plummeting (Lee et al., 2014).

Figure 1 Daily share prices and returns of the NES registered Firms in Kenya



Source: Nairobi Securities exchange (2023)

Figure 2 Monthly volatility of the NES registered firms in Kenya



Source: Nairobi Securities exchange (2023)

The stock markets are highly susceptible (Idrees et al., 2019). Therefore, assessing the volatility of the NSE is essential (Bhowmik & Wang, 2020). Various types of volatility models are justifiable, including the GARCH-type models. This study delved into generalized autoregressive conditional heteroskedasticity (GARCH) models. Previous studies have used the GARCH-type models to forecast the volatility of Bitcoins (Katsiampa, 2017; Guo, 2020;

Bergsli et al., 2022). However, most of these studies focused on the volatility of Bitcoin. The main used GARCH-type models used in previous studies are sGARCH, EGARCH, IGARCH, TGARCH, GJRGARCH, APARCH, and CGARCH (Chen et al., 2019; Chen et al., 2021; Naimy et al., 2021). Additionally, the studies focused on a few models. There is scanty information on the best suitable GARCH-type model for evaluating volatility. Therefore, there is a urgent need to evaluate the best GARCH-model in predicting the volatility of the stocks returns of the NSE listed firms in Kenya. To fill the study gap, we focused on the research question of which GARCH-type model is best suitable for assessing the volatility of NSE-listed firms' returns? This study's objective was to evaluate which GARCH-type model is suitable for forecasting the volatility of NSE-listed firms' returns.

Our study contributes to the literature in the following ways. First, it contrasts most studies evaluating the stock market performance and delves into volatility. Therefore, our study contributes to the NSE-listed firms' returns volatility. Second, enrich the literature on the GARCH model's predictability on the volatility of listed firms' NSE stock returns. Among the previous studies, Wanda et al. (2022) evaluated the effects of market rations on volatility using the Randon effect model. Korir (2018) assessed the volatility of daily and weekly returns on NSE using the standard GARCH model. Owido et al. (2013) modelled the efficiency of NSE using different GARCH order models, including GARCH (1,1), GARCH (2,1) and GARCH (3,1). To the best of our knowledge, most of these studies focused on one GARCH model or different order of the GARCH model and limited information on various GARCH-type models; therefore, this study fills the gap. Finally, our study recommends the best-fit GARCH-type model for predicting the volatility of the NSE-listed firms' returns.

The remaining sections of the paper are organized as follows. **Section 2** Literature review. **Section 3** highlights the data collection and econometric framework. **Section 4** focused on the results and supporting discussion. **Section 5** describes the results-based conclusion.

LITERATURE REVIEW

This section delves on the importance of theoretical foundation. Three main theories relevant to the study are highlighted.

Efficient Market Hypothesis

This hypothesis, proposed by Fama (1970), states that share prices reflect all the existing data about the marketplace, and no investor can reap surplus profits through the information available. Efficient market hypothesis (EMH) describes a market where several rational, active and profit maximizing investors strive to predict market value of securities, and critical contemporary information is costless in the market (Krishnan & Periasamy, 2022; Mutugi, 2022;). It is therefore difficult for investors to outperform the market since it is efficient. The theory further argues that most of the time, stock will trade at their fair value, thus it becomes a bit difficult for investors to purchase overvalued or undervalued stock; and should stock be undervalued, all investors would shift counters and create more demand hence the forces of demand and supply would move prices to equilibrium (Mohrschladt & Langer, 2020).

Efficient market hypothesis has three forms: weak form EMH which presumes that share price reflects the available information in the financial market, semi-strong EMH which states that share prices change as soon as the information is let out to the public domain, and strong EMH which asserts that share price is a reflection of both private and public information (Farooq & Sajid, 2015). Market information is therefore a determinant of investment decisions which affects share price. This explains why investors tend to trade on popular stocks even if there is no adequate information or evaluation on whether such stocks are likely to result into good returns (Ghelichi, Nakhjavan, Gharehdaghi, & Branch, 2016). Therefore, the EMH is key in making investments in the stocks markets including the NSE.

METHODOLOGY

Data

The data used are the daily share prices and volume of forty-nine (49) Kenyan Firms listed in the Nairobi Securities Exchange (NSE). The daily share prices and volume collected were obtained from NSE, available online at <https://www.nse.co.ke/>. Out of the 63 targeted NSE-registered firms, only 49 were registered before 2011. We collected daily data from the 49 NSE firms for ten years (1st January 2011 to 31st December 2020), a total of 2501 observations.

Investment returns are rewards for investors and primarily fluctuate over time (Urak & Bilgic, 2023). Social, economic, and political factors can induce changes due to quick responses to daily events (Tosun & Demirbas, 2020). The volatility of the prices of products sold by firms is determined by assessing the volatility of the data. Noteworthy, volatility is the directionless movement of a commodity in a given period. However, if evaluated for a short period, high

price fluctuation indicates high volatility, while low price fluctuation represents low volatility. The data depicts a heteroscedastic form if the fluctuations are not stable or constant over the assessment period. We calculated the returns accounting for the natural logarithm of the ratio of two consecutive prices (Equation 1).

$$r_t = 100 * \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (1)$$

Where:

r_t Is the returns
 P_t is the price at the reference day
 P_{t-1} is the lag operator of P_t .

Diagnostic Tests

We performed descriptive statistics and unit root tests. The descriptive statistics included measures of central tendency, dispersion, and distribution. We conducted the ARCH effect test to establish whether the data exhibited volatility. We tested the null hypothesis. Returns do not exhibit volatility over time. We subjected the data to Jarque–Bera (JB) test to establish whether the data indicated a [skewness](#) and [kurtosis](#) similar to [normal distribution](#). We conducted Phillips -Perron (PP) test and augmented Dickey-Fuller (ADF) unit root test to test for the null hypothesis that a unit root is present in a time series data. The main difference between PP and ADF tests is that the PP ignores any serial correlation while the ADF uses a parametric autoregression to approximate the structure of errors. However, the two test ends up with a similar conclusion.

Econometric Method

We used models that consist of an Autoregressive model for the conditional mean and a first-order GARCH-type model for the conditional variance, equations 2 and 3. We were interested in low-order models. The low-order GARCH models catch most of the nonlinearity of the conditional variance. Therefore, in this study, only the first-order models were presented.

$$V_t = c + \sum_{i=1}^s \phi_i V_{t-1} + e_t \quad (2)$$

$$e_t = W_i Y_t, Y_t \sim \text{i.i.d.} (0,1) \quad (3)$$

Where:

- V_t is the share price volatility on year t,
- e_t Is the error term,
- Y_t Is the white noise process while
- W_t Is the conditional standard deviation.

We used different GARCH-type models to assess the returns of NES-registered firms in Kenya (Table 1). The seven GARCH-type models used are standard GARCH (sGARCH), exponential GARCH (EGARCH), Integrated GARCH (IGARCH), Glosten-Jagannathan-Runkle GARCH (GJR-GARCH), Threshold GARCH (TGARCH), Asymmetric Power ARCH (APARCH) and Component GARCH (CGARCH).

Table 1 The GARCH -types of models used in the study

Model	Description	Equation	Proposed by
sGARCH	Generalized AutoRegressive Conditional Heteroskedasticity	$W_{t+1}^2 = \omega + \alpha e_{t-1}^2 + \beta W_{t-1}^2$	Engle (1982)
EGARCH	The exponential general autoregressive conditional heteroskedastic	$\log W_{t+1}^2 = \omega + \alpha \left[\frac{e_{t-1}}{W_{t-1}} - \sqrt{2/\pi} \right] + \beta \log(W_{t-1}^2) + \delta \frac{e_{t-1}}{W_{t-1}}$	Nelson (1991)
IGARCH	Integrated general autoregressive conditional heteroskedastic	$W_{t+1}^2 = \omega + \alpha e_{t-1}^2 + (1 - \alpha)W_t^2$	Engle and Bollerslev (1986)
GJR-GARCH	Glosten-Jagannathan-Runkle general autoregressive conditional heteroskedastic	$W_{t+1}^2 = \omega + \alpha e_t^2 + \gamma I(e_t < 0)e_t^2 + \beta W_t^2$	Glosten, Jagannathan and Runkle (1993)
TGARCH	The Threshold general autoregressive conditional heteroskedastic	$W_{t+1}^2 = \omega + \alpha e_{t-1}^2 + \beta W_{t-1}^2 + \gamma e_{t-1}^2 I_{t-1}$	Zakoian (1994)
APARCH	Asymmetric Power autoregressive conditional heteroskedastic	$W_{t+1}^\delta = \omega + \alpha (e_{t-1} - \gamma e_{t-1})^\delta + \beta W_{t-1}^\delta$	Ding et al. (1993)
CGARCH	Component general autoregressive conditional heteroskedastic	$W_{t+1}^2 = q_t + \alpha (e_{t-1}^2 - q_{t-1}^2) + \beta (W_{t-1}^2 - q_{t-1}^2)$ $q_t = \omega + \rho (q_{t-1}^2 - \omega) + \theta (e_{t-1}^2 - W_{t-1}^2)$	Ding and Granger (1996)

Source: Authors' analysis (2023)

We used three information criteria that is Akaike (AIC), Bayesian (BIC), Shibata, and Hannan-Quinn (HQ), to determine the optimal model for predicting the return of NES-listed firms in Kenya. The four information criteria consider how good the fitting of the model is and the number of parameters in the model, rewarding a better fitting and penalizing an increased number of parameters for given data sets. In this study, we selected the model with the minimum criteria values.

RESULTS AND DISCUSSION

Table 2 summarizes the returns of the NSE-listed firms in Kenya. The findings showed a daily return of 0.0009946% and a standard deviation of 0.03055501. The daily returns for the ten years (1st January 2011 to 31st December 2020) ranged from -0.3485577% to 0.4298643%. The findings revealed a positive (0.6388565) skewness and excess positive (35.28109) kurtosis, indicating the data exhibited a leptokurtic distribution.

Table 2: Returns descriptive statistics

Statistics	Value
Observations	2501
Mean	0.0009946
Standard Deviation	0.03055501
Median	0.000
Skewness	0.6388565
Kurtosis	35.28109
Minimum	-0.3485577
Maximum	0.4298643

Source: Authors' analysis (2023)

The diagnostic tests, namely JB, ARCH, PP, and ADF results, are presented in Table 3. The JB test (130663^{***}) is high and significant at 1%, indicating that the data is not normally distributed. The findings suggested that our returns departed from normality (Urak & Bilgic, 2023). The value of ARCH (5) = 316.17^{***}, significant at 1%, suggests an ARCH effect on the returns of NSE-listed firms in Kenya. The JB and ARCH (5) findings justified the use of GARCH-type models see Katsiampa (2017).

Table 3: Diagnostic test

Statistics	Value
Observations	2501
Jarque–Bera (JB) test	130663 ^{***} (<0.001)
ARCH (5)	316.17 ^{***} (<0.001)
Phillips–Perron (PP) test	-46.372 ^{***} (0.01)
augmented Dickey–Fuller (ADF) test	-12.75 ^{***} (0.01)

The values in parenthesis are the p-value. ^{***} shows a p-value of 1%.

Source: Authors' analysis (2023)

The findings showed a PP-test (-46.372^{***}) and ADF-test (-12.75^{***}) significant at 1%. Based on the unit-root test values, we reject the null hypothesis of a unit root for the returns of NSE-listed firms in Kenya. Therefore, the indicated returns of the NSE-listed firm in Kenya are stationary at 1% level of significance.

Table 4 shows the estimation results of the seven GARCH-type models for returns of the NSE-listed firms in Kenya. The GARCH-type models estimate results are organized as follows. First, we present the parameter estimators of the seven models. The results showed that the estimated coefficients were more significant than zero. Second, the evaluation of the best model using the information criteria.

The GARCH coefficients (β) and/ or (γ) for the sGARCH ($\beta=0.000000$), IGARCH ($\beta=0.000000$), EGARCH ($\beta=0.81615$ and $\gamma=1.57486$), GJR-GARCH ($\beta=0.000000$ and $\gamma=0.026899$), TGARCH ($\beta=0.000000$ and $\gamma=-0.074734$), APARCH ($\beta=0.000000$, $\gamma=-0.056977$) and CGARCH ($\beta=0.000000$ and $\gamma=0.995693$) were greater than zero. The findings suggested that there would be a crash so that the volatility of the return value for the leverage effect would have a significant effect. The findings suggested that from the models, the influence of bad news received will be greater in the volatility of return for the NSE-listed firms in Kenya than in the influence of good news. The finding collaborates with Katsiampa (2017) and Hidayana et al. (2021), who found that GARCH-type models bad news received was greater in the volatility of return for bitcoins than in the influence of good news.

According to the results, the log-likelihood (LL) is maximized under the APARCH model. The four information criteria (AIC, BIC, Shibata, and HQ) selected the APARCH model. Interestingly, all the estimated coefficients are significant at a 1% significance level for the APARCH model. The ARCH(5) and $Q(9)$ tests indicated that the APARCH model was justified for the NES-listed firms' returns. Moreover, we cannot reject the null hypothesis of no remaining ARCH effects and no autocorrelation.

Based on the study findings, the APARCH model is the best among the seven GARCH-type models in illustrating NES-listed firms' returns volatility. Our results were consistent with Bergsli et al. (2022), who found that the APARCH model best predicted the volatility of bitcoins returns.

Table 4 GARCH-type models estimation results

	sGARCH	IGARCH	EGARCH	GJR-GARCH	TGARCH	APARCH	CGARCH
(φ)	0.239907*** (0.009843)	0.239905*** (0.007277)	0.23883*** (0.000520)	0.240013*** (0.001726)	0.240571*** (0.007795)	0.239647*** (0.009072)**	0.240880*** (0.000763)
(ω)	0.000364 (0.000191)	0.000364*** (0.000082)	-1.10121*** (0.097475)	0.000370 (0.000064)	0.013110*** (0.003505)	0.006600 (0.010119)	0.000400*** (0.000012)
(α)	0.999000*** (0.223604)	1.000000*** (0.021186)	0.17011*** (0.035721)	1.000000*** (0.076343)	0.873863*** (0.069453)	0.910214*** (0.144201)	0.002139*** (0.000099)
(β)	0.000000*** (0.221570)	0.000000*** (0.00927)	0.81615*** (0.017324)	0.000000*** (0.021841)	0.000000*** (0.086486)	0.000000*** (0.011747)	0.989767*** (0.000160)
(γ)	-	-	1.57486***	-0.026899***	-0.074734***	-0.056977***	0.995693***

			(0.084153)	(0.077190)	(0.028010)	(0.032053)	(0.002330)
LL	2470.977	2471.028	2403.966	2471.107	2479.819	2481.311	2474.779
AIC	-1.9760	-1.9768	-1.9215	-1.9753	-1.9822	-1.9826	-1.9774
BIC	-1.9666	-1.9698	-1.9098	-1.9636	-1.9686	-1.9706	-1.9634
Shibat	-1.9760	-1.9768	-1.9215	-1.9753	-1.9822	-1.9826	
a							-1.9774
HQ	-1.9726	-1.9743	-1.9172	-1.9710	-1.9775	-1.9780	-1.9723
ARCH	0.134178	0.1352361	1.850	0.1389067	0.19846	0.19561	0.135092
(5)							
Q (9)	0.12520	0.21944	2.3571	0.22782	0.3673	0.32106	0.20775

The values in parenthesis are standard error; *** indicates significance at 1%.

Source: Authors' analysis (2023)

CONCLUSION

Understanding the volatility of the Nairobi Securities Exchanges listed firms is essential for managing risks. In this study, we evaluated which GARCH-type model was suitable for predicting the volatility of the Nairobi Securities Exchange-listed firms. We calculated the NSE-listed firms' returns and fitted GARCH-type models into the return data. We consider seven GARCH-type models: sGARCH, IGARCH, EGARCH, TGARCH, GJRGARCH, APARCH, and CGARCH. The models were compared based on goodness of fit using four information criteria: AIC, BIC, HQ, and Shibata. We found that the APARCH model was the suitable GARCH-type model for predicting NSE-listed firms' volatility. We recommend that investors apply APARCH to understand the volatility of NSE-listed firms' returns for making investment decisions and managing risks.

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