

Article

# Predicting Stock Price Volatility Using ARCH-GARCH Models

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**Abstract:** This paper aims to apply ARCH-GARCH models to evaluate their ability to predict stock returns volatility in financial markets to help better allocate resources, manage risks, and improve investment decisions. This study was conducted on daily data of Apple Inc. stock prices during the period from January 2, 2024, to December 30, 2024, with 251 observations. The results indicate that ARCH-GARCH models provide good daily forecasts of stock price movements and are able to capture the fluctuation series by choosing the appropriate model for the prediction process. The ARCH(1) model was the most suitable for predicting the stock returns series of the study sample.

**Keywords:** ARCH-GARCH, prediction, stock price, Apple

## 1. Introduction

This is a topic of great importance in studies of finance, econometrics and the academic world in general to predict stock returns (Dinardi, 2019:4). There are three important things that are captured within this interest. The initial observation is that stock market volatility has significantly increased compared to historical periods, attributed to institutional changes including the adoption of modern trading techniques, automation, and the introduction of derivatives, futures, and options trading contracts, all of which can result in substantial fluctuations in the average stock return. Second, although the tendency of stock market volatility to exhibit "clustering" has long been known, it is only since the introduction of the autoregressive conditional heteroscedasticity (ARCH) model by Engle (1982) and its subsequent generalization (GARCH) by Bollerslev (1986) that researchers have formalized financial time series models using econometric techniques. Third, the growing recognition of the practical importance of accurate volatility estimates and forecasts in asset and option pricing models, portfolio selection, and market timing decisions has led to a continuing examination of the stability of stock volatility and the accuracy of volatility forecasting techniques (McMillan & Apgwilym, 2000:435).

Accordingly, financial asset prices are random and not deterministic. Most researchers suppose that the changes in financial asset prices over short periods are lognormal random variables. Thus, variance of logarithmic prices is generally used as a measure of returns on financial assets and changes in relative prices, which will be normally distributed. The volatility is the measure of probability density dispersion. The standard deviation of a random variable is a common measure of dispersion and is equal to the square root of the variance. Since stock price changes are difficult to predict, it is often accepted by default that successive returns are approximately uncorrelated. However, significant efforts have been made in dealing with traditional econometric time series to sequentially analyze conditional volatility of the developed markets (Vasudevan and Vetrivel, 2016:1565). The econometric problem is to find what use can be made of this information in predicting the mean and the variance of returns.

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The mean return specification seemed to have been used in numerous specifications and in estimations to forecast future returns, however, comparatively very few methods existed before the advent of ARCH models.

This Arch model may be called the beginning model because it says that the variance of tomorrow's returns is equal to the evenly weighted sum of the squared residuals over the previous 22 days. This is an assumption we wish to avoid, as it is rational to believe that current events are more significant. Furthermore, discarding weights for observations older than one month is equally undesirable. Engle (1982) introduced the ARCH model, which allows for the calculation of these weights as parameters. The model uses the data to calculate the appropriate weights for forecasting variance. (Engle, 2001). This model is also useful in its generalization to the GARCH parameter described by Bollerslev (1986). It also is a weighted average of the past squared residuals, but with decreasing weights and weights that never weight exactly zero. Usually parsimonious, they are easy to estimate and, however simple, have turned out to predict conditional variances surprisingly well. The most popular GARCH specification states that the best predictor of variance for the next period is a weighted average of the long run average variance, the conditional expectation for the variance in this period, and news for the variance in this period, which is the last squared residual (Engle, 2001).

### 1.1. ARCH model

This means that (autoregressive conditional on the inhomogeneity of variance), is abbreviated in two parts, AR (Autoregressive) or the autoregressive mean and CH (Heteroscedasticity Conditioning) or the inhomogeneity (instability) of the variance, that is the variance depends on the past of the series and varies with time. Second, the ARCH model has practical relevance, as the uncertainty concerns the uncertainty related to a given investment through time. (AL-Masoodi& Pele,2023:271)

But changes in time period do change uncertainty in forecasting; they are not just functions of forecast expectations. Most financial variables for time series are non-linear dynamics and unstable volatility in time, with an asymmetric phenomenon that Box-Jenkins models do not take; Nevertheless, when it comes to time series concerning the development of financial variables. It justifies the use of non-linear variance models (ARCH) and is (ARMA), hence, justifying that.

The first to propose ARCH models was the researcher Engle in 1982. This model means that volatility is not constant in the current period (t) and is linked to its inconsistency in previous time periods and can be written in the following mathematical form: - (Huang, at al, 2023) (Yunita, 2016)

$$a_t^2 = a_t + a_1 a_{t-1} + a_2 a_{t-2} + a_p a_{t-p} \quad \text{where } p, 1 \dots, 0, i, > 0 \quad a_i \dots (1)$$

So when  $p = 1$  based on the above equation, we get the mathematical formula for the ARCH model:

$$a_t^2 = a_t + a_1 a_{t-1} \dots (2)$$

It has an unconditional contrast property known as:

$$a_x^2 = \frac{a_0}{1 - a_1}$$

### 1.2. GARCH Model

It Can Also Be Extended As (Bollerslev) In 1986 Extended The ARCH Model To A More General Heteroscedastic Conditional Autoregressive Model With Some Differences. The variance in the previous period was, however, not the only thing it depended upon; it also depended upon the square of the error in (t). (Alberg,at al,2014) (Toong,at al,2023)

$$a_t^2 = a_t + a_1 a_{t-1} + a_2 a_{t-2} + \dots + a_p a_{t-p} + \beta_1 a_{t-1}^2 + \beta_2 a_{t-2}^2 + \dots + \beta_q a_{t-q}^2 \dots (3)$$

The above equation can be written in the following form:

$$a_t^2 = a_0 + \sum_{i=1}^p a_i a_{t-i} + \sum_{j=1}^q \beta_j a_{t-j}^2 \quad \text{where } \sum_{i=1}^p a_i + \sum_{j=1}^q \beta_j < 1 \dots (4)$$

### 1.3. Literature Reviews

In previous studies, ARCH-GARCH models have been used and some of them are like: Mandelbrot (1963) and Fama (1965) who analyzed the statistical properties of stock returns. Akgeri (1989) even takes it further in the same field, he not only looked into statistical properties, but also backed up his statements regarding the forecasting abilities of ARCH and GARCH models relative to EWMA (exponentially weighted moving average) as well as the historical simple average method. GARCH models were found to be generally better than most alternative competitors. The study of McMillan, at al (2000) found that GARCH models offer better daily forecasts, but the most reliable

forecasting performance is enjoyed by the moving average and GARCH models. Al (2008) also demonstrates, that the asymmetric GARCH model with thick tailed densities improves the overall fit of the conditional variance measure and that the EGARCH model with the skewed Student t distribution outperforms in forecasting the TASE indices. Garcia (2005) developed a GARCH approach for forecasts of hourly prices in the unregulated electricity markets in Spain and California. For years studied the forecast error associated with Spanish and Californian market data, which ranged from the average forecast error of about 9% depending on which month of the year was being studied. The ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) models are extensively employed to forecast stock price volatility, defined as the extent of fluctuation in stock prices over time. These models facilitate the comprehension and prediction of volatility fluctuations based on past data, which is essential for financial decision-making. The ARCH model posits that volatility is affected by previous error terms, whereas the GARCH model expands this concept by incorporating historical volatility as a predictor. The output indicated, of a time series with volatility, price spike, the GARCH model outperformed the general ARIMA model. Using daily data, Alam, al (2013) did the volatility forecast of DSE20 and general DSE Indices using the ARCH model. For the purpose of the study, different benchmark models were proposed: GARCH, EGARCH, PARCH and TARARCH. The period covered from 1st December 2001 to 14th August 2008 and 18th August 2008 to 10th September 2011 are the in sample and the out of sample groups respectively. In the attempt to predict the daily closing stock prices of the Nigerian Stock Exchange using linear GARCH model, Arowolo (2013) showed that GARCH model was considered the best fit for the time varying volatility of the data.

Vasudevan & Vetrivel (2016) Acquired data in daily time series was also used to model and forecast volatility of returns of the BSE-SENSEX index of the Indian stock market for the period from July 1, 1997 to December 31, 2015.

## 2. Materials and Methods

The data consists of (251) daily observations of Apple Inc. price movement from 1/2/2024 to 12/30/2024, which were obtained from finance.yahoo.com. Apple Inc. was chosen because it is considered one of the largest companies in the world and provides accurate historical data that researchers can use to better test various financial models.

The study problem includes the continuous and unexpected large fluctuations in stock prices in financial markets, which push investors to make irrational investment decisions because they are not based on a future vision or tools that give them a future idea about price movement. Accordingly, this paper aims to shed light on the statistical models used in the forecasting process, especially ARCH-GARCH models, to test their ability to predict stock returns fluctuations in financial markets to contribute to better resource allocation, risk management, and improving investment decisions. This study is based on the hypothesis of the possibility of predicting future prices using ARCH-GARCH models.

In order to carry out this study we used the ARCH-GARCH method which was used to analyse the data in different stages using the Eviews12 program, the first stage of which was a descriptive analysis of Apple Inc. historical price series and its normal distribution test, the second stage was the ARCH effect test to ensure the existence of the problem of heteroscedasticity in the variance of the residual of the price series., the third step is to choose the appropriate model according to the lowest value of the criteria (AIC) (SIC) (H-Q), the fourth step is to evaluate the chosen model, and the last step is to predict using the chosen model and the internal prediction was made for the same period.

## 3. Results and Discussion

In this section, we try to test the ARCH-GARCH models to predict the movement of Apple Inc (APP) stock prices, by reviewing the data description and normal distribution, testing the heterogeneity of the data, testing the appropriate model, and then predicting the stock returns of the study sample company.

### 3.1. Data Description

This study relied on applying ARCH-GARCH models to daily data on Apple Inc stock price movements during the period from January 2, 2024 to December 30, 2024, with (251) observations, using the Eviews12 program for the application aspect.

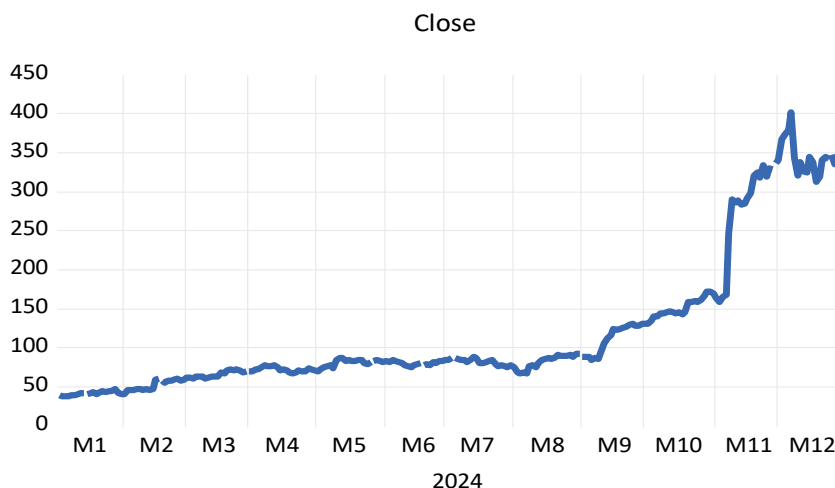


Figure (1) Variation in Apple Inc price movement in 2024  
Source : Eviews12 program

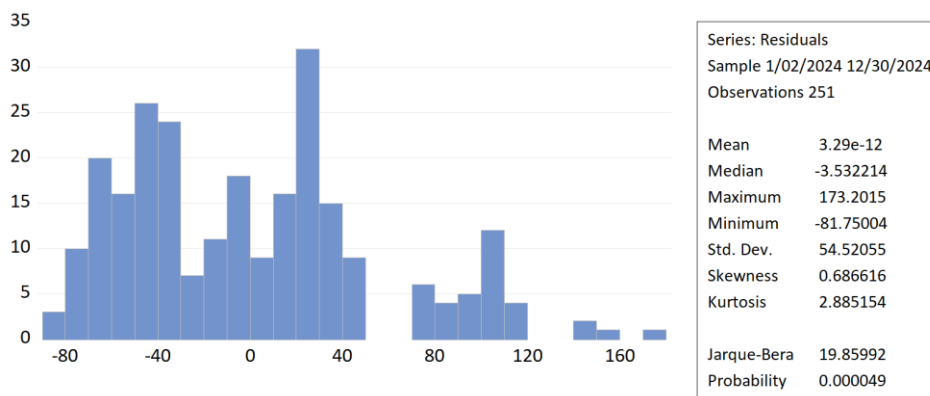


Figure (2) Statistical description and normal distribution of Apple Inc stock data  
Source : Eviews12 program

The data on the right side of Figure (2) presents the statistical analysis of the company's price series volatility. The Mean is 3.29, the Median is -3.53, the Maximum is 173.20, and the Minimum is -81.75. The standard deviation is 54.52, and the Skewness value is 0.68, indicating a right-tailed distribution of errors. The Kurtosis value is 2.88, which is less than 3, suggesting a flattened shape of the normal distribution, corroborated by the Jarque-Bera test. The probability is 0.000049, which is below the significance level of 0.05, indicating that the series does not conform to a normal distribution.

### 3.2.Heteroscedasticity Test

To determine the presence of a problem of heteroscedasticity in the variance of errors in the Apple Inc stock price series, we conduct the ARCH test.

Table (1) ARCH test for heteroscedasticity in the variance of random errors.

Heteroskedasticity Test: ARCH			
F-statistic	1552.293	Prob. F(1,248)	0.0000
Obs*R-squared	215.5612	Prob. Chi-Square (1)	0.0000

Source : Eviews12 program

Table (1) shows that the ARCH test shows that the Probability of both the F-statistic and Obs\*R-squared is (0.0000), which is less than the significance level of (0.05). This indicates the existence of a problem of heterogeneity of error variance for the stock price series of the study sample company.

### 3.3. Model Fit Test

In this section, we conduct a trade-off test on the selected models to obtain the best model for predicting future returns on Apple Inc stock movement. This is done by relying on the lowest value obtained by the (AIC), (SIC), and (H-Q) criteria shown in Table (2).

Table (2) Results of testing the appropriate model for the price of Apple Inc shares

Models	Akaike information criterion (AIC)	Schwarz Information Criterion (SIC)	HannanQuinn Criterion (H-Q)
ARCH(1)	9.812185	9.868367	9.834794
ARCH(2)	9.881932	9.952160	9.910193
ARCH(3)	9.959440	10.04371	9.993354
ARCH(1.1)	9.904312	9.974540	9.932574
ARCH(2.1)	9.915874	10.00015	9.949788
ARCH(3.1)	10.02514	10.12346	10.06471
GARCH(2.1)	9.992228	10.07650	10.02614
GARCH(2.2)	10.02207	10.12039	10.06163
GARCH(3.2)	10.04165	10.15402	10.08687

Source : Eviews12 program

Table (2) shows that the ARCH(1) model is the appropriate model for predicting the stock prices of the study sample company, as it achieves the appropriateness conditions that depend on the lowest value of the criteria (AIC) (SIC) (H-Q), which is the lowest compared to other models.

### 3.4. Evaluation of the ARCH(1) Model

To test the solution to the problem of heteroscedasticity of the price series using the ARCH(1) model, we perform the ARCH test, as shown in Table (3)

Table (3) ARCH Test for Heteroscedasticity of Random Error Variance

Heteroskedasticity Test: ARCH			
F-statistic	0.220222	Prob. F(1,248)	0.6393
Obs*R-squared	0.221881	Prob. Chi-Square (1)	0.6377

Source : Eviews12 program

Table (3) shows that the ARCH test shows that the Probability of both F-statistic and Obs\*R-squared is (0.6393) and (0.6377) respectively, which is higher than the significance level of (0.05). This indicates the homogeneity of error variance for the stock price series of the study sample company. These results give strength to this model.

### 3.5. Volatility Forecasting

After identifying and evaluating the appropriate model, in this section we perform the forecasting process using internal forecasting for the same sample period, then predicting the future values of Apple Inc stock prices using Eviews12.

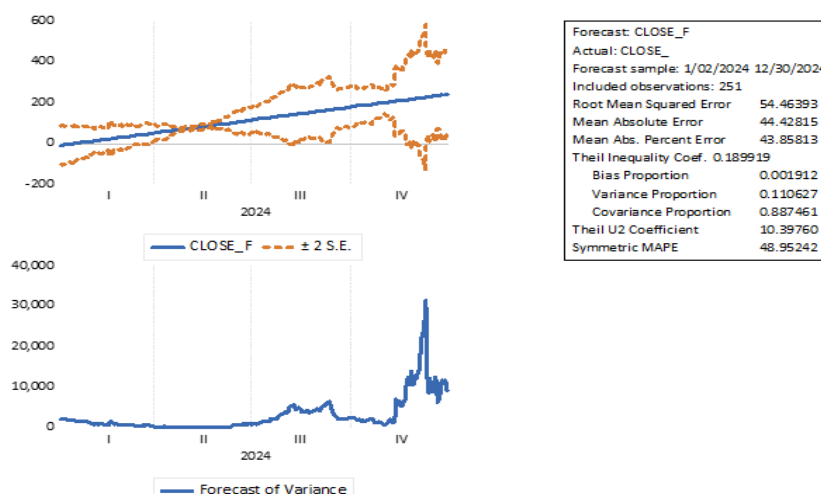


Figure (4) Internal forecast of Apple's price movement variance during the period from January 2, 2024 to December 30, 2024

Source : Eviews12 program

Figure (3) shows the internal forecasting process (previous period) represented by the dashed line, as the ARCH(1) model shows the ability to determine values within a range of ( $\pm 2$ ) standard deviations compared to the actual values, and this indicates the predictive ability of the model.

#### 4. Conclusions

The techniques played in this study was to assess the feasibility of using ARCH GARCH mathematical models to forecast stock return volatility in financial market in order to inform investors and policymakers on making informed decision and managing their risk more effectively. The data used in this study is daily Apple Inc. stock prices from January 2, 2024 to December 30, 2024 with 251 observations. The predictive capability of ARCH GARCH models was studied by examining different distributions in order to detect the best model, by means of the minimum values taken into consideration by the criterion (AIC), (SIC), and (H-Q). ARCH (1) model was the most efficient to capture the dynamic characters of the stock returns of the sample company studied herein. Internal prediction assessment was shown to be strongly correlated against the actual values on this model.

#### References

1. MCMillan, D., Speight, A., & Apgwilym, O. (2000). Forecasting UK stock market volatility. *Applied Financial Economics*, 10(4), 435-448.
2. Vasudevan, R. D., & Vetrivel, S. C. (2016). Forecasting stock market volatility using GARCH models: Evidence from the Indian stock market. *Asian Journal of Research in Social Sciences and Humanities*, 6(8), 1565-1574.
3. Engle, R. (2001). GARCH 101: The use of ARCH/GARCH models in applied econometrics. *Journal of economic perspectives*, 15(4), 157-168.
4. Akgiray, V. (1989). Conditional Heteroscedasticity in Time Series of Stock Returns: Evidence and Forecasts. *Journal of Business*, 62:55-80.
5. Fama, E. (1965). The Behaviour of Stock Market Prices. *Journal of Business*, 38:34-105.
6. Mandelbrot, B. (1963). The Variation of Certain Speculative Prices. *Journal of Business*, 36: 394-419.
7. Alberg, D., Shalit, H., & Yosef, R. (2008). Estimating stock market volatility using asymmetric GARCH models. *Applied Financial Economics*, 18(15), 1201-1208.
8. Garcia, R. C., Contreras, J., Van Akkeren, M., & Garcia, J. B. C. (2005). A GARCH forecasting model to predict day-ahead electricity prices. *IEEE transactions on power systems*, 20(2), 867-874.
9. Alam, M. Z., Siddiquee, M. N., & Masukujjaman, M. (2013). Forecasting volatility of stock indices with ARCH model. *International Journal of Financial Research*, 4(2), 126.
10. Arowolo, W. B. (2013). Predicting stock prices returns using GARCH model. *The International Journal of Engineering and Science*, 2(5), 32-37.
11. Lestari, E. P., Prajanti, S. D. W., Wibawanto, W., & Adzim, F. (2022). ARCH-GARCH analysis: An approach to determine the price volatility of red chili. *AGRARIS: Journal of Agribusiness and Rural Development Research*, 8(1), 90-105.
12. Dinardi, F. B. (2019). *Forecasting the stock market using ARIMA and ARCH/GARCH approaches* (Master's thesis, Universidade NOVA de Lisboa (Portugal)).
13. AL-Masoodi, S. O. J. & Pele, D.T (2023). Using ARCH and GARCH mathematical models to predict the general budget deficit for the period from (2008) to (2023). *Wasit Journal for Pure sciences*, 2(4), 269-277.
14. Huang, X., You, P., Gao, X., & Cheng, D. (2023, July). Check for updates Stock Price Prediction Based on ARIMA-GARCH and LSTM. In *Proceedings of the 2nd International Academic Conference on Blockchain, Information Technology and Smart Finance (ICBIS 2023)* (Vol. 14, p. 438). Springer Nature.
15. Yunita, I. (2016, March). Volatility Modeling Using ARCH/GARCH Method: Application on Asia Pasific Index. In *3rd International Seminar and Conference on Learning Organization* (pp. 182-189). Atlantis Press.
16. Toong, D., Goh, K. W., & Sim, Y. W. (2023). Estimation of stock market index volatility using the GARCH model: Causality between stock indices. *Asian Economic and Financial Review*, 13(3), 162-179.