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Modeling and forecasting volatility in the Iraq stock exchange: A survey study using ARCH and GARCH models

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Abstract

This study aimed at the effectiveness of self-regression models conditional on the instability of variance ARCH in predicting the returns of shares traded for the Iraq Stock Exchange, in addition to the possibility of proposing a model in providing predictions with relatively small errors during the period from 5/1/2021 to 18/10/2024 by daily observations over the studied period, and to achieve the objectives of the study, the daily closing price was calculated as an indicator to predict fluctuations and estimate self-regression conditional on the instability of variance based on self-regression models conditional on heterogeneity variance. ARCH: "Auto Regressive Conditional Heteroscedasticity" and GARCH: "Generalized Auto Regressive Conditional Heteroscedasticity" are intended to model variance in data that have different fluctuations (different variability) in time series periods, i.e. have high variance sometimes and low variance across different time periods of the time series. For financial analysts, these patterns promise a period of wild and calm.

Keywords: GARCH-ARCH patterns, stock market index, closing price, forecast

Introduction

The Iraq stock exchange is of economic importance to financial institutions and companies, as it provides regulations and means that contribute to achieving justice, efficiency and transparency for financial transactions within the market, as it provides a reliable and reliable financial time series under which the investment decision-making process is carried out. as the financial time series has time periods of variations and turns due to the complex characteristics that characterize it, in addition to its unexpected random movement over time, which increases the uncertainty and makes predicting its metabolite trends accurately faces difficulty (Zakaria & abdalla: 2012) ^[22], and given the important role of predicting fluctuations and metabolite fluctuations of the stock market index traded on a daily basis in the investment decision-making process, which in turn requires the use of quantitative analytical models through which a mathematical model can be formulated that fits with the nature of the financial time series on the one hand and is able to predict metabolic trends (Caporin and Storti: 2020) ^[8].

The paragraph aims to see what has been adhered to by researchers and their findings within the field of research, for the purpose of enriching the subject of research and obtaining knowledge accumulation: (Brodocianu: 2015) ^[6] The study was conducted in the field of financial market return modeling, which aimed to analyze the CAC40 index and the European Euro Eurinext 100 index using autoregressive models conditional on instability of variance ARCH, for a period of ten previous years, and the study confirmed the importance of diversification in increasing returns and reducing risks, and the study also confirmed that due to the instability of the variation of financial chains of both indicators, the predictive model, which was confirmed to determine the shocks witnessed by these two indicators, is the regression model. Self-conditioned by the instability of exponential Generalized ARCH (EGARCH). (Benelbar, 2021) ^[4] The aim of this article is to study the possibility of modeling

the sharp fluctuations of the returns of the CAC 40 index on the Paris Stock Exchange, caused by the Corona Covid pandemic using GARCH models, through 2091 daily views of the index's returns. The study found through a comparison between several models that the autoregressive model conditioned by the instability of variance has modeled the CAC 40 index return chain despite the sharp fluctuations, as the returns follow the ARMA model (1,1), while the remainders follow the GARCH (1,1).

Finally the descriptive analytical approach was used as a tool to understand and analyze data descriptively by following methodological steps, and (ARCH & GARCH) models were relied on in modeling the volatility of the Iraq Stock Exchange Index. Statistical programs (E-VIEWS 13) were used to analyze data and model fluctuations.

The research problem

The research problem lies in the interpretation of financial fluctuations in stock prices that occur in the Iraq Stock during the period of daily trading and prediction, that the analysis of these fluctuations through self-regression models conditional on heterogeneity of variance and autocorrelation models conditional on generalized heterogeneity variance GARCH-ARCH, and the effectiveness of models in modeling closing price fluctuations.

Iraq Stock Exchange market

From 1992 to 2003, it was known as the Baghdad Stock Exchange, established by Law No. 24 of 1991. It was a government-owned market with 113 Iraqi joint-stock companies. It was closed on March 19, 2003, and renamed the Iraq Stock Exchange (ISX) on April 18, 2004, under Provisional Law No. 74. It operates under the supervision of the Iraqi Capital Market Authority, an independent body similar to the US Securities and Exchange Commission. In 2005, it became the sole market in Iraq, with 15 listed companies at its opening, and now more than 100 companies. Daily trading volume reached approximately five million dollars, and key companies include Bank of Baghdad, Baghdad Beverages Company, and Iraqi Carpets and Furniture.

Stocks

A share can be defined as a document that represents a shareholder's interest in the capital of a company. Shares have the following characteristics because the company's capital is divided into equal shares (Wang and Vrijling 2005) [21]. Equality in the value of shares implies equality in the rights granted by shares. This means that they require equal access to the company's profits and equal voting rights at general meetings. It also provides for equality of obligations arising from shareholding. However, such equality is contrary to public policy and the legislator allows the company to issue preferential shares with more rights than ordinary shares by resolution of an extraordinary general meeting of shareholders if there is no express prohibition in the company's articles of association (Saleem and Sági, 2012). (Saleem and Sági (2021) [15], the tradability of shares, in other words, the freedom to buy and sell shares, is one of the most important features that distinguish them from partnership shares in private companies. Due to the position held by the identity of a partner in a private company, these shares can be transferred to others only after obtaining the consent of the other partners. As regards joint-stock companies.

Financial Time Series Analysis

The statistical analysis of financial time series is a rich and diverse field of study that, because of its importance in analyzing the behavior of various phenomena over a specific period of time, requires an interdisciplinary approach due to its inherent complexity, combining many disciplines such as statistics, economics, and financial accounting. The analysis of financial time series is done through a variety of scientific contributions that explore different lines of research in this field. In recent years, there have been several distinctive trends in the development of research on financial time series analysis. These are: richer and stronger links with other disciplines, greater diversity in the topics addressed, a focus on increasingly complex models, and a renewed interest in the role of computational techniques. (Tsay & Chen: 2018) [19].

ARCH (p)Auto Regressive Conditional Heteroscedasticity

These models consider the case of instability or variability and aim to model variability. ARCH models (Autoregressive Conditional Heteroskedasticity models) are important in modeling high or low volatility associated with the time of traded financial assets, and are the first tool to describe the fluctuations of the standard deviation using constant values for past volatility or fluctuations. They are based on the assumption that the current volatility of traded financial assets is a function of past volatility. In other words, the volatility in a given time period is affected by the volatility in previous periods. This indicates that the conditional variance (volatility) of the previous data is not constant (Sezer and Ozbayoglu, 2020) [16]. ARCH models provide a way to estimate and predict volatility, which is crucial for managing financial institutions and companies. ARCH is a fundamental tool in econometrics for capturing and modeling volatility clusters in financial time series data. This model is used to study and model time series volatility. It has gained significant popularity due to its ability to calculate the changing variance of financial returns over time. (Engle (1982) [10] proposed a non-linear model expressing autoregression that includes non-homogeneous conditional variance. To build an ARCH model, the first step is to build an AR model for the financial time series, then test ARCH on the residuals of the estimated model, then determine the order of the ARCH model and perform the estimation, and finally test the model's suitability for the financial time series data. If the fit is not achieved, the process of determining the order of the model and estimation is repeated (Srihari and Chetanraj, 2024) [17]. The ARCH model can be as:

$$X_t = \mu + \varepsilon_t \quad (1)$$

$$\varepsilon_t = \sigma_t e_t \dots \dots e_t \sim N(0,1) \quad (2)$$

$$E(\varepsilon_t | \varepsilon_{t-1}) = 0 \quad (3)$$

$$E(\sigma_t^2 | \varepsilon_{t-1}) = \sigma_t^2 \quad (4)$$

When (ε_t) are Normal distribution:-

$$\sigma_t^2 = \alpha_0 + \alpha_i \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \quad (5)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 \quad (6)$$

Where: $(0 < 1, 0 < \alpha_0, 0 \leq \alpha_i)$ (Enders, 2010) [9].

- **AR:** represents a slow-interval autoregressive model (p).
- **CH:** Represents conditional variance and depends on (t-1) the pre-viewing periods within time series.
- **(X_t):** financial time series.
- **(μ)** represents the conditional average of the time financial series.
- **(ε_t):** the amount of the residual series of the financial time series.
- **(e_t):** independent random variables and assumes symmetry of normal distribution with mean = 0, and variance = 1.
- **(σ_t²):** the amount of conditional variance.
- **(α_i):** Parameters of the estimated model

ARCH models are also reproached for their need to estimate a large number of parameters to determine the rank of the most efficient model, in addition to estimating many values of (p), which in turn leads to obtaining a negative value for (α_i), which causes errors in estimating the assumptions of the (ARCH) model.

GARCH (p,q) Generalized Auto Regressive Conditional Heteroscedasticity

The expansion of the estimation of p-values for ARCH models, which in turn produces a negative magnitude of (α_i), which causes errors and contradictions with the assumptions of the ARCH model, and to get rid of this problem with consideration of the conditional variance of errors, generalized autoregression conditional on heterogeneity GARCH (p,q) was proposed by (Bollerslov, 1986) [5] to address the negative subtleties of (α_i) in the ARCH model. Where the proposed model interpreted conditional variance as a function of slow random error squares in addition to the fixed limit, where the GARCH(p,q) model can be described as follows (TSAY, 2002) [20]:-

$$\sigma_t^2 = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \dots + \beta_q \sigma_{t-q}^2 \quad (7)$$

Whereas, equation (7) is interpreted in terms of the mean (0 < α₀), the squares of the residuals for late periods (ε_{t-i}²) and the predictions of variance for previous periods (σ_{t-q}²)

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \beta_j \sigma_{t-j}^2 \quad (8)$$

α₀: Constant

α_i : Model parameter of ARCH i=1,2,3,.....q

β_j : Model parameter of GRACH j=1,2,3,.....p

α_i expresses short-term persistence of shocks, and β_j expresses long-term persistence of shocks (Lim & Sek, 2013) [12]. As assumed (Alexander and Lazar, 2006) [3] for parameters of the model (ARCH) and the model (GARCH):-

$$\alpha_i \geq 0 \quad i = 1, 2 \dots \dots p$$

$$\beta_j \geq 0 \quad j = 1, 2 \dots \dots q$$

In addition to the condition of stability and continuity of oscillations in order for the equation of the model to be stable, it is:

$$\sum_{i=1}^p \alpha_i + \sum_{j=1}^q \beta_j < 1 \quad (9)$$

Where (α_i + β_j > 1) where it is assumed to use GARCH (p,q) models that ensure continuity of variance. GARCH models are seen as a method that provides better measures of financial risk, than can be obtained by tracking standard deviation, and many studies have relied on GARCH models to analyze the relationship between stock prices. Where there is heterogeneity in variance, observations do not correspond to the linear pattern, as they tend to cluster or stack, so if statistical models based on variance stability are used on these data, the conclusions and predictive value that can be drawn from the model will not be reliable and efficient in predicting and estimating (Abuzayed, and Nedal, 2021) [2].

The Stationary

Achieving stability is one of the basic conditions for modeling the time series according to the Box-Jenkins methodology, which is achieved by examining the stability of the series in the arithmetic mean and variance, and the graph of the original series is used to observe the general direction of the series, and the series is unstable on average if it includes irregular oscillations, this means that it has a dispersion around the variance, as well as if it has a general face, this indicates that the series is unstable in the middle. For the purpose of making the financial time series stable in variance, we use logarithmic transformations, but on average, differences are taken to make it stable on average (Jeribi and Ghorbel, 2022) [11], as we sometimes notice and from observing the graph, it is difficult to determine the nature of the time series as it enjoys stability with mean and variance (Said, 2006) [14], where some statistical tests are relied on to contribute to revealing the stability of the financial time series.

Autocorrelation Function (ACF)

The autocorrelation function is one of the tools for detecting stability for the time series, where the autocorrelation function shows the amount of correlation between observations for different time periods, and it highlights some important characteristics of the financial time series, where we estimate the autocorrelation function of the financial time series to clarify the preference of the model used in forecasting, where it is adopted through the results if the values of the autocorrelation coefficient of random error are within the confidence interval (95%) Reflect the suitability of the model to describe and model the time series in estimation and forecasting. It is symbolized by the symbol (ρ_k) and its value is estimated within the range (+1 to -1) and is formulated according to the following equation (Sultan and Ali, 2019) [18].

$$\rho_k = \frac{\gamma_k}{\gamma_0} \quad (10)$$

$$\gamma_k = \text{cov}(Y_t, Y_{t-k}) \quad (11)$$

Partial Autocorrelation Function (PACF)

The partial autocorrelation function is an indicator to measure the linear relationship between (Y_t, Y_{t-k}) for the observations of the financial time series, as it is an indicator for diagnosing the appropriate model for the financial time series from among a set of assumed models, as well as contributing to determining the rank of the model and its suitability for the series data by testing the normal distribution of residual errors, and is used in addition to the autocorrelation function (ACF) to distinguish between different models. It is formulated according to the following mathematical formula (Ramsey, 1974) [13]:-

$$\Phi_{kk} = \frac{\rho_k - \sum_{j=1}^{k-1} \Phi_{k-1,j} \rho_{k-j}}{1 - \sum_{j=1}^{k-1} \Phi_{k-2,j} \rho_j} \quad (12)$$

and, $k = 2, 3, 4, \dots, n$

$$\Phi_{kj} = \Phi_{k-1,j} - \Phi_{kk} \Phi_{k-1,k-1} \quad (13)$$

and : $(j = 1, 2, \dots, k-1)$

Arch Effect Test

Ljung-box test for self-correlation test of residual squares (ε_t^2) using the statistical test (Ljung-box) (Q_m) which takes the following formula (Burns, 2002) [7]:

$$Q_m = T(T+2) \sum_{k=1}^m \frac{\hat{\rho}_k^2}{T-k} \sim X^2(m-p) \quad (14)$$

Where T is the number of time series views, and m: number of autocorrelation coefficients (number of displacements) p: estimated model rank (estimated parameter), and $\hat{\rho}_k^2$: autocorrelation coefficients. Where the value of ($Q_m < X^2\alpha(m-p)$) is tested and compared, and if the condition is met, this indicates that the residue series does not suffer from autocorrelation or if it is ((p-value ≥ 0.05), i.e. there is no effect of heterogeneity of variance (GARCH), and therefore the null hypothesis is accepted, meaning that the residual series of suffers from autocorrelation. Where through this test, Comprehensive testing of the remainder, which indicates the difference in time period between current and previous

observations, i.e. viewing (Y_t) comes after viewing (Y_{t-1}) after a time period of (K) ((Srihari and Chetanraj, 2024) [17], 2018). Engle (1982) [10] proposed the special Lagrang Multiplier-LM test in the ARCH impact test by testing the following hypothesis

H_0 : no arch effect or H_1 : there is arch effect.

where (T) : the size of the time series, (p): the number of estimated parameters, (R^2) the coefficient of determination according to the following formula

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \quad (15)$$

By comparing the statistical value (TR^2) with the tabular value (X_p^2) and at the level of significance (95%), where if (X_p^2) is smaller than (TR^2) or the P-value of this statistic is smaller than the level of significance, we accept the alternative hypothesis that there is an effect of (ARCH) in the proposed model (Wang et al., 2005) [21].

Case Study

The researcher used the practical side on the daily closing price of the stock index in the Iraq Stock Exchange for (1-1-2020 to 7-10-2024) the daily index in order to choose the appropriate model for modeling the financial chain of the share price, and this period was chosen due to the state of economic instability in Iraq, where the days of non-trading were excluded from the financial time series to obtain (1059) views.

The Normal distribution and The Stationary of the financial time series

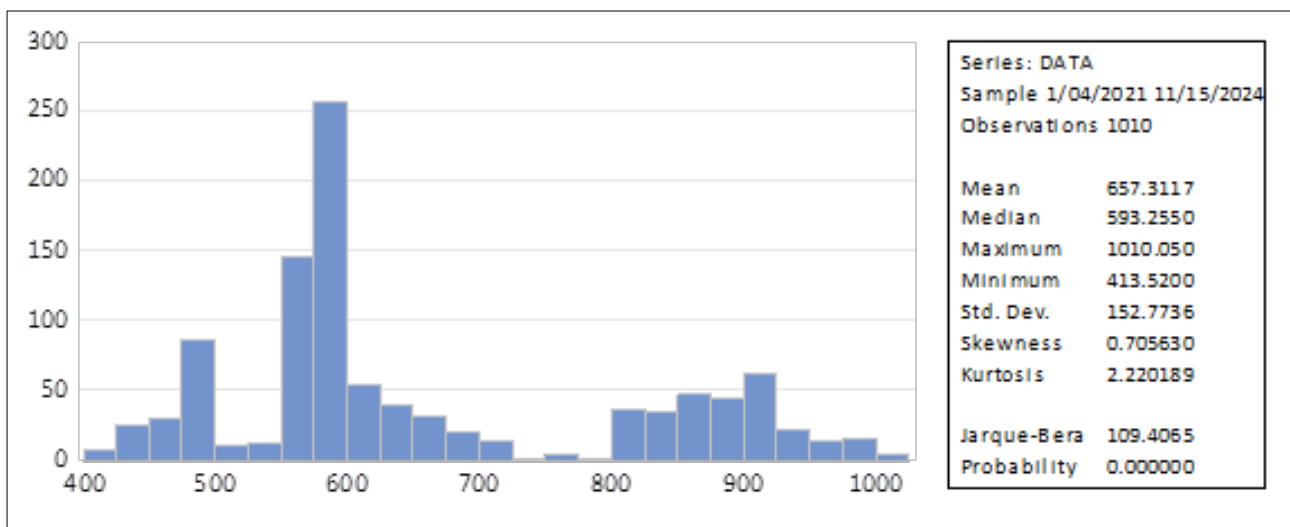


Fig 1: Descriptive Statistics Scales for Financial Time Series

We find from Figure (1) descriptive statistics scales, where we find that the time series of the closing price index does not follow the normal distribution during the time period (4-1-2021 until 15-11-2024), where the (Jarque-Bera) test recorded a significant level less than (5%) and this is what characterizes the financial time series, and we also note that the financial time series has fluctuations and fluctuations through the high standard deviation coefficient (152.7736) and the highest value

was recorded (1010.05), while the lowest value was recorded (413.520) and the torsion coefficient was recorded (0.705630) and it is considered approximately. Acceptable within the range (+1 to -1) of the normal distribution of data, and the flattening coefficient was recorded which reached (2.156) less than (3). The stability test of the time series of the stock price index of the Iraq Stock Exchange was conducted during the time period (2-1-2020 until 7-10-2024), as shown in Figure (2)



Fig 2: Daily closing price index

Figure (2) shows that the daily closing price index series is non-linear and contains clear fluctuations in its daily behavior resulting from the change in the closing price from one period to another, which documents the instability of the financial time series..

Unit root test

In order to verify the stability of the time series, the Augmented-Dickey-Fuller (ADF) test was performed to test that the financial time series is stable on average.

Table 1: Unit Root Test Results

ADF-Augmented Dickey Fuller	DATA		At First Difference	
	Prob.	t-Statistic	Prob.	t-Statistic
With constant	0.4572	-1.6488	0.0000	-25.2896
With constant and trend	0.4956	-2.1875	0.0000	-25.2999
Without constant and trend	0.4327	-1.8889	0.0000	-25.2254

Where we note through the moral significance of the test (ADF test) for the three models are smaller than (5%) after calculating the first difference of the financial time series and thus deduce the stability of the time series on average after calculating the first difference of the financial time series to achieve stability, and the following figure shows that the financial time series is stable and free of the roots of the unit and thus avoid us in obtaining false and unstable results

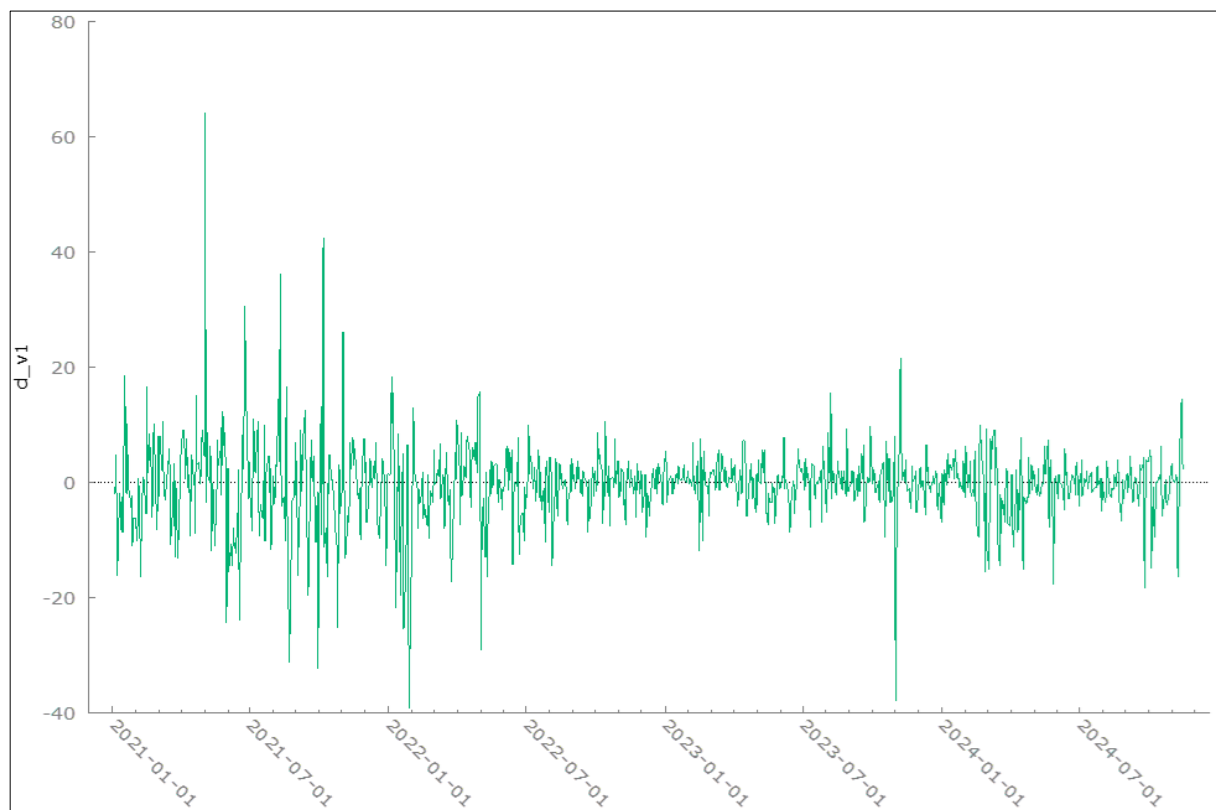


Fig 3: Financial time series after calculating the first difference

The effect test for (Arch) for the financial time series

H₀: Homogeneous variation of the time series (no effect of ARCH).

H₁: Heterogeneity of time series variation (there is an effect of ARCH).

Table 2: Impact Test Results for (ARCH)

Heteroskedasticity Test: ARCH			
F-statistic	16.59542	Prob. F(1,1006)	0.0000
Obs*R-squared	16.35856	Prob. Chi-Square(1)	0.0001

Significance for the (ARCH) test was recorded at (0.000) for both (F-Statistic and Observed R-Square), which is less than (5%) at a lag period (1), confirming the presence of the effect of variation in the closing price index during the time period specified for the study, and this A sign of heterogeneity of variance and the presence of an effect of (ARCH). Thus, we reject the null hypothesis and accept the alternative hypothesis indicating heterogeneity of variance. Which indicates the use of (ARCH) models to get rid of the problem of heterogeneity

of variance, and thus the models can be estimated using (GARCH).

Autocorrelation and partial correlation of the financial time chain.

The statistics of (Q-stat) were relied on for the (Box-Ljung) test for the autocorrelation test of the residues (errors are not distributed randomly, according to the following hypothesis :

H₀: The remainders are distributed randomly

H₁: The residuals are not randomly distributed

Table 3: Autocorrelation and partial financial time series.

Included observations: 1059							
Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob		
		1	0.997	0.997	1055.1	0.000	
		2	0.993	-0.073	2103.4	0.000	
		3	0.989	-0.024	3144.4	0.000	
		4	0.985	-0.000	4178.3	0.000	
		5	0.982	0.039	5205.5	0.000	
		6	0.978	0.014	6226.3	0.000	
		7	0.975	0.005	7241.0	0.000	
		8	0.971	0.016	8249.8	0.000	
		9	0.968	0.004	9252.8	0.000	
		10	0.965	0.011	10250.	0.000	
		11	0.961	-0.052	11241.	0.000	
		12	0.958	0.018	12226.	0.000	
		13	0.955	0.018	13205.	0.000	
		14	0.951	-0.014	14179.	0.000	
		15	0.948	0.014	15146.	0.000	
		16	0.945	0.019	16108.	0.000	
		17	0.942	0.009	17065.	0.000	
		18	0.939	0.008	18017.	0.000	
		19	0.936	-0.010	18964.	0.000	
		20	0.933	-0.025	19905.	0.000	
		21	0.930	0.016	20841.	0.000	
		22	0.927	0.003	21772.	0.000	
		23	0.924	-0.005	22698.	0.000	
		24	0.921	0.026	23618.	0.000	

The above table shows the difference in the values of the autocorrelation coefficient from zero at a significant level (1%), where we note that it tends to decrease in all displacements and the longer the displacement period, and we also note that all the probability values of the (Q-stat) test are less than (5%), and this indicates the lack of independence of the observations from each other, and the dependence of the current values on the previous value, that is, the effect of the nearest previous values is higher than the effect of the previous values farther away, Thus, we accept the alternative hypothesis that the residues are not randomly distributed as well as the existence of self-correlation of the remainders. In other words, there is an effect of (ARCH) and therefore there is a state of

heterogeneity, i.e. (Heteroscedasticity), meaning that large changes in the financial chain are followed by small changes, but without the possibility of knowing the direction of these dependent changes. ARCH models provide the appropriate means of analyzing the financial time series.

Model estimatio ARCH & GARCH

At this stage, the parameters of autoregressive models conditioned by heterogeneity of variance (ARCH GARCH) are estimated. To reach the best and most efficient model to represent the financial time series of the originator of the closing price of the Iraq Stock Exchange with the assumption that the errors are distributed normally.

Table 4: Estimated parameters of (ARCH)

Models	μ	α_0	α_1	α_2	α_3	α_4
ARCH (1)	-0.009962	0.013853	0.685611			
significant	0.0101	0.0000	0.0000			
ARCH (2)	-0.010137	0.013919	0.708603	-0.009346		
significant	0.0091	0.0000	0.0000	0.0005		
ARCH (3)	-0.010035	0.01389	0.675609	-0.0096	0.003398	
significant	0.0112	0.0000	0.0000	0.0000	0.2829	
ARCH (4)	-0.005451	0.011616	0.449775	-0.009346	-0.012235	0.541049
significant	0.2420	0.0000	0.0000	0.0000	0.0000	0.0000

We note from the table above, that the fixed limit coefficient is significant at all models (ARCH) except for the ARCH (4) model, where it was maintained due to the presence of an average trend in the financial time series, where the first

difference was calculated calculating the models, and we also note that the parameter (α_3) does not differ significantly from zero at the ARCH (3) model. The following table shows the estimate of the parameters of the model (GARCH):

Table 5: Estimated parameters of (GARCH)

Models	μ	α_0	α_1	β_1	α_2	β_2
GARCH (1,1)	0.007912	0.001989	0.211363	0.5615395	--	--
significant	0.0000	0.0000	0.0000	0.0000	--	--
GARCH (1,2)	0.007122	0.001769	0.209518	0.319278	--	0.336468
significant	0.0492	0.0000	0.0000	0.0000	---	0.0000
GARCH (2,1)	0.007167	0.001741	0.201437	0.706589	0.775276	---
significant	0.0441	0.0000	0.0000	0.0000	0.0000	----
GARCH (2,2)	-0.006987	0.001197	0.210693	0.411926	0.620288	0.172637
significant	0.2302	0.0000	0.0000	0.0000	0.0000	0.0000

Where the estimated results of the model coefficients for (GARCH) indicate that the fixed limit differs significantly from zero for all estimated models, except for the GARCH model (2,2) in the arithmetic mean equation, where it was not significant significantly, and we also note that the model GARCH(1,1) is one of the best models estimated according to the estimated statistical parameters, and to ensure and verify the quality of the estimated model through comparison between the values of the differentiated criteria, Akai (AIC), Schwartz Standard (SIC) and Hanan-Coin (H-Q). Then after that, the appropriate model for the financial time series data is determined, which will be used to estimate the future fluctuations of the financial time series, based on comparative criteria (AIC, SIC, H-Q)

Table 6: Criteria for differentiation between models.

Models	(H-Q)	(SIC)	(AIC)
ARCH(1)	3.660722	3.866322	3.652954
ARCH(2)	3.841392	3.849862	3.836238
ARCH(3)	3.838849	3.850143	3.831956
ARCH(4)	3.787904	3.804915	3.777665
GARCH(1,1)	3.658944	3.673143	3.650716
GARCH (1,2)	3.700693	3.768764	3.690747
GARCH (2,1)	3.838902	3.855878	3.833125
GARCH (2,2)	3.661154	3.767653	3.65279

Where we note from the above table, that the model GARCH(1,1) is ahead of other estimated models, because it has the lowest value of the differentiation criteria, and thus the estimated model GARCH(1,1) is the best model for estimating and modeling the fluctuations of the financial time series, and thus the model can be formulated for the equation of the average and conditional variance:-

$$X_t = 0.007912 + \varepsilon_t \quad (16)$$

$$\sigma_t^2 = 0.001989 + 0.211363\varepsilon_{t-1}^2 + 0.561539\sigma_{t-1}^2 \quad (17)$$

The magnitude (0.007912) represents the value of the constant for the average equation, where it recorded a significant significance less than (5%), and the value of (α_0) reached (0.001989), which is greater than (0) and with a positive sign and significant significance less than (5%), as it is a function of the condition of the model ($0 < \alpha_0$). The value of the estimated parameter of the constant for the ARCH model was (0.211363) with a significant significance of less than (5%), as it indicates the existence of an effect of (ARCH) on the fluctuations of the financial time series, and the value of the constant for ARCH was within the range between (0.1), which indicates the stability of error boxes in the previous periods of the financial time series. While the amount of the constant for the GARCH model (0.5615395) with statistical significance is less than (5%), where this value indicates the existence of the shock effect of (GARCH) conditional variance on the fluctuations of the financial time series, and we also note that the value of the constant for (GARCH) was within the range (0.1) and indicated the stability of conditional variance in the period prior to the financial time series. The (GARCH) models provide us with the advantages of calculating the continuity of fluctuations and fluctuations by calculating the values of the constant for the (ARCH & GARCH) model, where the more the value of the constant for the estimated models. We find that the sum of the estimated value of the constant:

$$0.211363 + 0.5615395 = 0.7729025 \quad (18)$$

is less than (1), as it indicates that there is continuity of the impact of shocks and near and far information on the fluctuations of the financial time series, as it indicates that the future variation will remain conditional on current and infinite shocks, and we also note that the value of the constant for the (ARCH) model is less than the value of the constant for (GARCH), which trusts that the effect of distant shocks is less than the impact of near shocks.

Check the suitability of the Model

At this stage, the efficiency of the estimated model is tested through the (Ljung-Box) test and the (ARCH-LM) test for the

residue and squares of the residues, as shown in the following table containing the (Ljung-Box) test:-

Table 7: Test for (Ljung-Box) for the remainder of the estimated model

Q-statistic probabilities adjusted for 1 dynamic regressor								
Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob	
				1	-0.001	-0.001	0.0007	0.980
				2	0.003	0.003	0.0083	0.996
				3	0.016	0.016	0.2796	0.964
				4	-0.033	-0.033	1.4356	0.838
				5	-0.060	-0.060	5.3033	0.380
				6	-0.002	-0.002	5.3072	0.505
				7	-0.026	-0.025	6.0481	0.534
				8	-0.006	-0.006	6.0898	0.637
				9	-0.003	-0.007	6.0989	0.730
				10	0.042	0.039	7.9803	0.631
				11	-0.025	-0.027	8.6564	0.654
				12	-0.049	-0.053	11.179	0.514
				13	-0.017	-0.020	11.501	0.569
				14	-0.057	-0.055	15.020	0.377
				15	-0.030	-0.026	15.986	0.383
				16	-0.005	-0.011	16.013	0.452

Table 8: Model suitability test according to (ARCH-LM)

Heteroskedasticity Test ARCH			
F-statistic	0.137048	Prob. F(1,1054)	0.7113
Obs*R-squared	0.137290	Prob. Chi-Square(1)	0.7110

Where we note through Table (6) and Table (7) that the probability value for testing the suitability of model D statistically through the (Ljung-Box) test as well as according to ARCH-LM and through the value of the (Observed R-Squared & F-Statistic) test has recorded a significant greater than (5%) and indicates that there is no effect of (ARCH) in the rest of the estimated model, as well as indicates that the problem of fogs and heterogeneity of data in the model is addressed. This model is the best to blame and in order to confirm the predictive ability of the estimated model, and the test of predictive power criteria (root mean squared error

(RMSE), (Mean Absolute Error (MAE)) and (average absolute error ratio) were relied upon. Mean Abs. Percent Error (MAPE)) to test the predictive accuracy of the model, if the value of the Thiel coefficient is equal to zero, this indicates the blindness of the high ability of a predictor, but if it is equal to one or greater than that, it reflects the weak ability of the model to be blind to predict or cannot be used for prediction, as well as indicates that there is no expected change over time, the greater the value of the Thiel coefficient for one, the lower the predictive ability of the estimated model.

Table 9: Comparison criteria

The Models	MSE	RMSE	MAPE	Thiel U
ARCH (1)	0.18484	0.42993	0.50120	0.576198
ARCH (2)	0.18601	0.43128	0.05035	0.577106
ARCH (3)	0.18707	0.43253	0.05042	0.576713
ARCH (4)	0.19227	0.43849	0.05087	0.576831
GARCH (1,1)	0.18476	0.42983	0.05010	0.575038
GARCH (1,2)	0.18498	0.43009	0.05012	0.575898
GARCH (2,1)	0.18582	0.43106	0.05025	0.578392
GARCH (2,2)	0.19664	0.44344	0.05081	0.587208

The above table showed the standard values of the proposed predictive model comparison, as all the criteria of differentiation achieved the lowest values at the estimated model GARCH(1.1) as well as for the coefficient (Thiel U) where the lowest value was recorded at the estimated model, and this value indicates to the coefficient (Thiel) that the estimated model has great accuracy and high possibility of prediction compared to other models. These results confirm the

effectiveness of the estimated GARCH models in modeling the Iraq Stock Exchange index.

Forecasting: This stage represents the main objective of studying the financial time series of the Iraq Stock Exchange, where the estimated model was relied on to predict future values, where the following figure shows the predicted values of the financial time series.

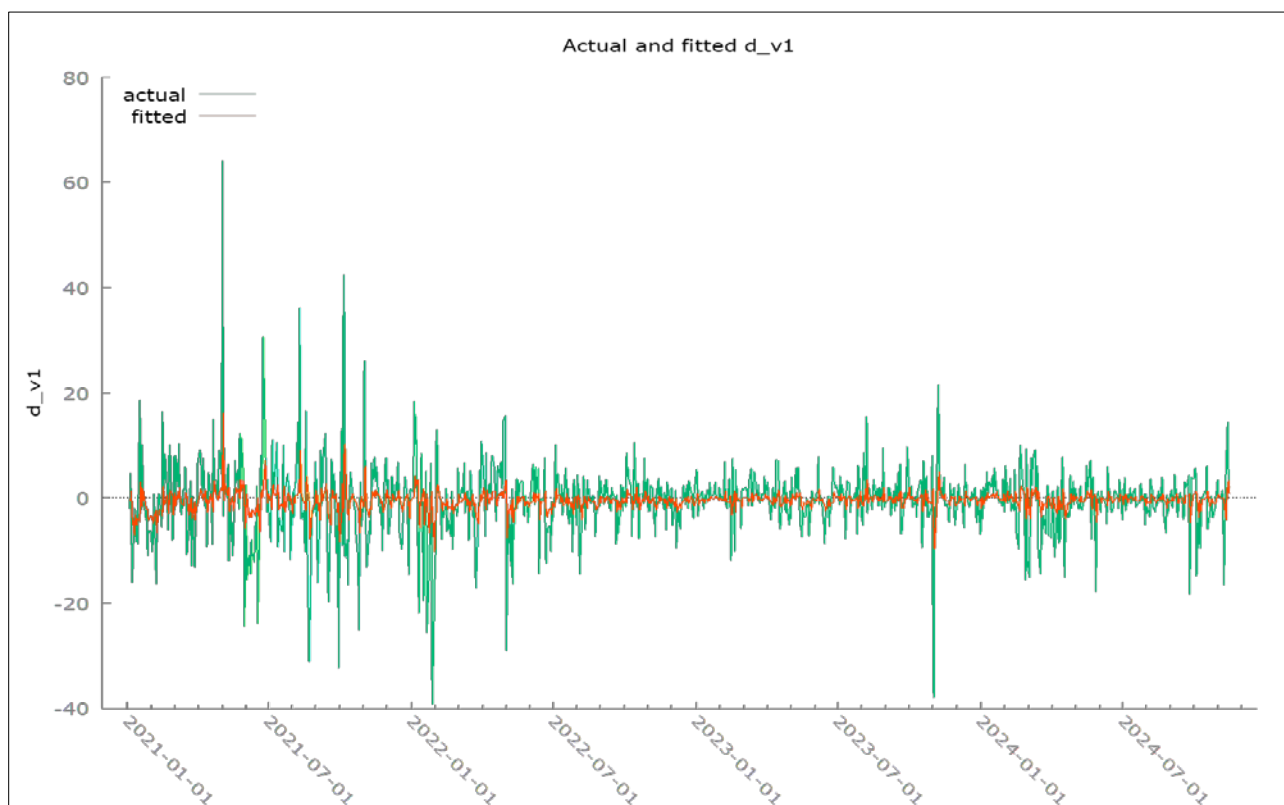


Fig 4: The Actual and the fitted values

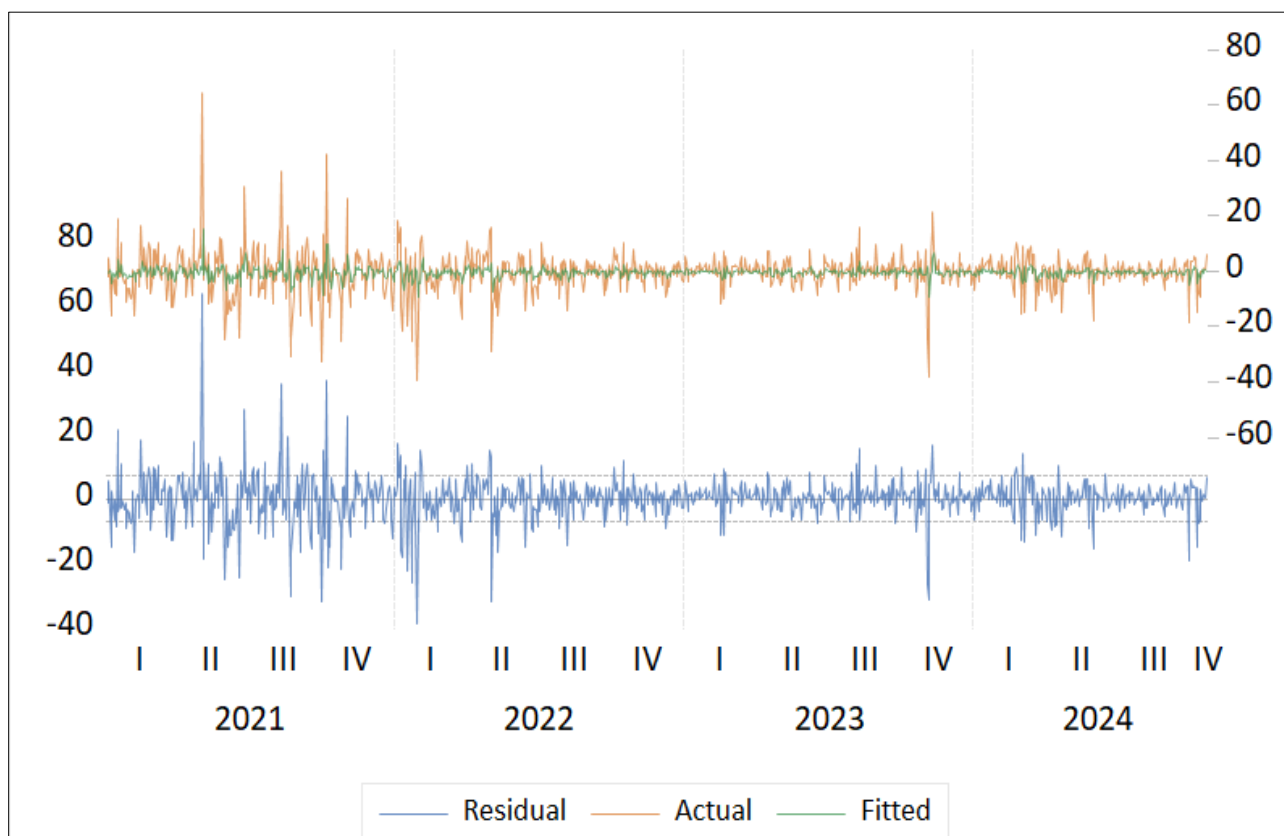


Fig 5: the Residual

Based on the proposed model, the closing price index of the Iraq Stock Exchange was predicted as in Table (6) and Figure (6).



Fig 6: The Actual and the fitted and the Predicted values

Table 6: Predictive values and confidence limits for the number of monthly accidents

Period	Actual data	Predicted values
10/19/2024	1073.84	1072.859
10/20/2024	1077.87	1077.416
10/21/2024	1076.99	1077.226
10/22/2024	1068	1067.152
10/23/2024	1061.83	1061.805
10/24/2024	1059.19	1058.798
10/25/2024	1054.42	1054.219
10/26/2024	1053.73	1054.251
10/27/2024	1059.47	1059.709
10/28/2024	1047.61	1047.627
10/29/2024	1043.11	1043.182
10/30/2024	1031.4	1032.359
10/31/2024	1033.13	1033.923
11/1/2024	1036.8	1036.632
11/2/2024	1030.36	1030.309
11/3/2024	1033.86	1034.363
11/4/2024	1031.92	1031.454
11/5/2024	1033.84	1034.406
11/6/2024	1018.57	1019.421
11/7/2024	1021.32	1022.098
11/8/2024	1031.11	1030.178
11/9/2024	1039.1	1038.149
11/10/2024	1043.62	1044.441
11/11/2024	1055.51	1056.169
11/12/2024	1055.25	1055.607
11/13/2024	1061.23	1061.502
11/14/2024	1055.15	1056.083
11/15/2024	1057.35	1058.203
11/16/2024	1051.59	1050.722
11/17/2024	1057	1056.649
11/18/2024	1068.42	1069.013
11/19/2024	1068.06	1067.294
11/20/2024	1064.53	1065.526
11/21/2024	1055.6	1056.551
11/22/2024	1053.81	1054.238

Conclusions

1. The closing price index was modeled according to (ARCH & GARCH) models, the study reached a set of conclusions, including.
2. The results of the preliminary tests Ljung-Box and ARCH-LM found that the variations of the errors of the daily return chain of the financial index and thus the validity of the application of the GARCH methodology.
3. The study found that the model GARCH (1,1) recorded the lowest value of the criteria of differentiation, including the coefficient (Theil U) and found that the estimated model has great accuracy and high predictability compared to other models in describing the behavior of conditional variation of the closing price index of the Iraq Stock Exchange.
4. The results of the unit root test showed that the series achieved stability after calculating the first difference, where the proposed models were estimated through the first differences of the financial series of the Iraq Stock Exchange Index.
5. It was found that the financial time series suffers from the effect of heterogeneity of variation during the time period, as the effect of (ARCH) and (GARCH) was evident in the residual series.

References

1. Abdullah SM, Kabir MA, Jahan K, Siddiqua S. Which model performs better while forecasting stock market volatility? Answer for Dhaka Stock Exchange (DSE). *Theoretical Economics Letters*. 2018;8(14):3203-3222.
2. Abuzayed B, Al-Fayoumi N. Risk spillover from crude oil prices to GCC stock market returns: New evidence during the COVID-19 outbreak. *The North American Journal of Economics and Finance*. 2021;58:101476.
3. Alexander C, Lazar E. Normal mixture GARCH (1,1): Applications to exchange rate modelling. *Journal of Applied Econometrics*. 2006;21(3):307-336.
4. Benelbar MH, Gherbi H, Bedrouni A. The possibility of using auto regressive conditional heteroskedasticity in modeling CAC 40 returns under the Corona pandemic. *International Journal of Economics and Policy*. 2021;4(1):82-100.
5. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*. 1986;31(3):307-327.
6. Brodocianu M. The analysis of the CAC 40 national index and of the Euronext 100 PAN-European index using ARCH models. *Procedia Economics and Finance*. 2015;27:548-555.
7. Burns P. Robustness of the Ljung-Box test and its rank equivalent [Internet]. 2002 [cited 2025 Feb 13]. Available from: <https://ssrn.com/abstract=443560>
8. Caporin M, Storti G. Financial time series: Methods and models. *Journal of Risk and Financial Management*. 2020;13(5):86. DOI: 10.3390/jrfm13050086.
9. Enders W. *Applied econometric time series*. 3rd ed. New York: John Wiley & Sons; 2010. p. 155.
10. Engle RF. Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*. 1982;50(4):987-1007.
11. Jeribi A, Ghorbel A. Forecasting developed and BRICS stock markets with cryptocurrencies and gold: Generalized orthogonal generalized autoregressive conditional heteroskedasticity and generalized autoregressive score analysis. *International Journal of Emerging Markets*. 2022;17(9):2290-2320.
12. Lim CM, Sek SK. Comparing the performances of GARCH-type models in capturing the stock market volatility in Malaysia. *Procedia Economics and Finance*. 2013;5:478-487.
13. Ramsey FL. Characterization of the partial autocorrelation function. *The Annals of Statistics*. 1974;2(6):1296-1301.
14. Said H. An economic study of the phenomenon of inflation in Algeria [Master's thesis]. Kasdi Merbah University - Ouargla, Faculty of Law and Economic Sciences; 2006.
15. Saleem A, Bárczi J, Sági J. COVID-19 and Islamic stock index: Evidence of market behavior and volatility persistence. *Journal of Risk and Financial Management*. 2021;14(8):389.
16. Sezer OB, Gudelek MU, Ozbayoglu AM. Financial time series forecasting with deep learning: A systematic literature review (2005-2019). *Applied Soft Computing*. 2020;90:106181.
17. Srihari G, Kusuma T, Chetanraj DB, Kumar JS, Aluvala R. Predictive modeling of return volatility in sustainable investments: An in-depth analysis of ARIMA, GARCH, and ARCH techniques. *Investment Management & Financial Innovations*. 2024;21(1):213.
18. Sultan W, Mohammed B, Rasheed M, Ali Y. The reality of the production of the main cereal crops in Iraq and their impact on food security for the period (1995-2016). *Tikrit Journal for Agricultural Sciences*. 2019;19(3):80-90.
19. Tsay RS, Chen R. *Nonlinear time series analysis*. John Wiley & Sons; 2018. Vol. 891.
20. Tsay RS. *Analysis of financial econometrics*. John Wiley & Sons, Inc; 2002.
21. Wang W, Van Gelder PM, Vrijling JK, Ma J. Testing and modelling autoregressive conditional heteroskedasticity of streamflow processes. *Nonlinear Processes in Geophysics*. 2005;12(1):55-66.
22. Zakaria S, Abdalla S. Modelling exchange rate volatility using GARCH models: Empirical evidence from Arab countries. *International Journal of Economics and Finance*. 2012;4(3):216-229.
23. Zakoian JM. Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*. 1994;18(5):931-955.