

Stock Price prediction based on AR-ARCH model: A Case Study of ICBC

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Abstract. Accompanying the progress of economy and financial market, the stock market has become one of the investment channels for many people. Therefore, it is of great practical significance to forecast the stock price with High accuracy. Based on the model of Autoregression (AR) and Autoregressive conditional heteroskedasticity (ARCH) models, this paper collects the daily closing share price of Industrial and Commercial Bank of China from 1st January 2018, to 1st June 2021. An AR-ARCH model is established to analyze the model based on the time series under the difference method, and then to forecast the stock price of ICBC in the next 10 days. The predicted stock price is applied to compare with the actual observed value. At last, the conclusion that AR-ARCH model is a suitable model for forecasting volatility and return is drawn. After choosing the fitting model as the AR-ARCH model, the result can be got more quickly and conveniently when people forecast and analyze the volatility and return of a stock. In this way, it can reduce the risk of market volatility according to the forecast of the model and make the investment more stable. Moreover, it can also promote the further study of the AR-ARCH model, and study the uniqueness and universality of the model.

Keywords: AR-ARCH model; Time Series; Stock forecast.

1. Introduction

As a part of the capital market, the stock market is closely related to the national economy. The goodness of the substantial economy could significantly affect the operation of the stock market. In a similar way, The trend and volatility of the stock market price and the investors' financial behavior are also mutually dependent. Stock Price is influenced by many factors, such as the economic cycle, financial policy, and the international environment, so it can be seen that the movement direction of the stock price is unknown and complex. Investors are also distracted in stock market trading by Information asymmetry, big-client manipulation, and herd mentality. As a result, a range of literature has researched stock price variation and stock price prediction, and it is very important to make a reasonable price prediction.

In recent years, the new eco-finance industry is rising rapidly. It is finally the integration of internet finance or Traditional Bank. However, traditional banking is indispensable to internet finance, and Internet finance is also inseparable from traditional banking [1]. At present, third-party payment still needs to rely on bank card payment, cannot be separated from the traditional bank, and exist independently. ICBC, as a state-owned bank, was established on 1st January 1984, to serve the industrial and commercial sector, fulfill the functions of the central bank, implement monetary policy, and make regulations for the emerging China financial market. It then continued to expand its business to more diverse aspects, increasingly focusing on risk management and profitability. In the mid-1990s, ICBC transformed into a commercial bank that separated policy loans from commercial loans and became a member of the "Top 4" commercial banks in China. In 1994, the country established three development banks -- the Agricultural Bank of China (ABC), the Bank of China (BOC), and the China Development Bank (CDB) -- to finance large-sized projects in the country. In other words, they took the role of operating the policy lending functions of the Top 4 state-owned commercial banks [2]. ICBC has more than 190 billion Yuan of enterprise annuity funds under its management, and its share in the enterprise annuity account management and custody market is more than 40%, ranking first in the market [3]. In the first half of 2021, the global epidemic situation is still evolving, the external environment is still increasingly severe and complex. For institutional and

inter-bank deposits, ICBC still ranks first among its peers. In terms of corporate financing, the number of clients has exceeded 9,602,000. Outstanding corporate loans reached 12.1 trillion Yuan, up 9 percent. Corporate deposits totaled 13.31 trillion Yuan, up 4.4 percent. For transaction banking, that's RMB 8, 850 billion [4].

To predict the stock price of such an enterprise can test the influence of the stock market more accurately. If the model can fit such a large financial enterprise that is closely related to the financial market and the stock market, then similar methods can fit other businesses and help people cope better with the market.

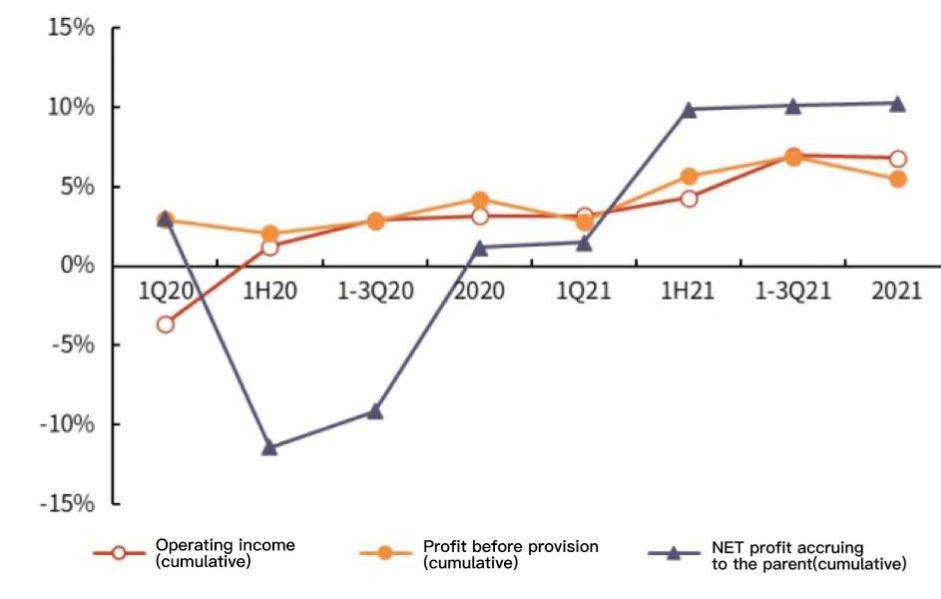


Figure 1. The cumulative growth rate of ICBC's revenue and earnings.
Sources: Company announcement, Everbright Securities Institute.

The profit growth rate rises quarter by quarter, the strategic layout advances steadily. In 2021, ICBC's revenue rose 6.8 percent year on year to 942.762 billion yuan, and its net profit for the parent rose 10.3 percent year on year to 348.338 billion yuan. Compared with 1-3Q21, year-on-year growth was -0.2 pct., and 0.1 pct., respectively. The profit growth rate has been rising quarter by quarter since 3Q21, and the total profit ranks first in the global banking industry. ICBC's impressive record suggests that it is worth investing in. If the model can be applied to predict the movement of stock price, then people can control the risk as much as possible to make a more appropriate investment.

Over the years, researchers have come up with various forecasting methods and models, such as statistical and probability-based ARM (autoregressive Moving-average model), VAR (Vector autoregression), based on the non-statistical principle, GM, SVM, Ann Innovative Forecasting model, grey forecasting method, artificial neural network method and so on. However, these methods and models cannot guarantee the accuracy and stability of the prediction, and they are difficult to adapt to the trend of data change. Whether people study the price trend or the fluctuation of the stock market, the stock data used are high-frequency time series such as daily data and weekly data. The traditional prediction methods and models have some limitations to the study of high-frequency time series, which require the utilization of updated models to solve this situation.

In recent years, there are many domestic research results on time series data change and fluctuation by using the ARMA model, ARCH model, and GARCH model. Wang found that the use of the high-order regression ARCH model can greatly improve the accuracy of stock price prediction [5]. Hebenlan used ARMA and ARCH models to forecast stock prices [6]. The result shows that the ARCH model predicts more precisely than that of the ARMA model. By using GARCH-type models, Wang and Wu derive the model and forecast the volatility and return of the CSI 300 Index series with

ideal results [7]. Wang et al. found that the second-order ARCH model fits the price fluctuation of soybean futures in China market. The price fluctuation of soybean futures is positively influenced by the previous two days' price [8]. Li et al., use different time series methods to fit and forecast the logarithmic value of the top 4 big banks' daily returns [9]. In the paper, the ARMA model's prediction fits the best, and ARMA- GARCH model ranks second. Li found that the ARMA-ARCH model can eliminate linear dependence and the ARCH effect, and produce a good prediction effect [10].

To sum up, domestic scholars study the time series models of stock price prediction at different levels and find their respective applicable scenarios and practical application value. At the same time, the short-term forecast and volatility fit are carried out, and some investment suggestions of reference value are obtained. A range of literature above suggest that the ARMA-ARCH model has its dominating advantages over other models. Hence, this paper implements the AR mean value equation and the residual term of the mean value equation (ARCH model) to deal with the issue of conditional heteroscedasticity, In other words, the AR-ARCH model is established to improve the AR model of sample daily return series.

In this paper, the AR-ARCH model is constructed to predict the short-term stock price trend accurately. The chosen data is ICBC's daily closing share price from 1st January 2018, to 1st June 2021. First, the stationary of stock returns is tested and then the mean-value equation AR model is constructed by the PACF test. Through the ARCH Effect Test and PACF test of $\{\sigma_t^2\}$, the variance equation ARCH equation is constructed, and thus the AR-ARCH model is constructed. Finally, the volatility and return of the stock price are fitted to predict the overall situation. After confirming the model, the market volatility risk can be reduced according to the model forecast. While making the investment more stable, it can also promote further research of the AR-ARCH model. At the same time, this paper could help make more understanding of the trend of price fluctuation and the determination of the price in the stock market. If the model and predicted value fit well with the real data, this contributes to the application to the other shares and even other derivatives in the financial market.

This article will expand on these aspects: first of all, the AR-ARCH model and data selection are introduced. Secondly, the empirical analysis of the AR-ARCH stock price forecasting model (including the results of model estimation and empirical analysis) is carried out. Finally, the conclusion is drawn.

2. Methodology and Data

2.1 AR-ARCH Model

The auto-regressive Model (AR Model) is the simplest ARMA model, which only uses time series Y_t different lag terms as explanatory variables, and describes the statistical regularity of a variable's change. The model is as follows: $Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + \varepsilon_t$. Where $\Phi_1, \Phi_2, \dots, \Phi_p$ is the auto-regressive coefficient, P is the auto-regressive order, the number of explanatory variables in the model, and $\{\varepsilon_t\}$ is the White noise with a mean of zero.

In the financial market, asset yield often shows the characteristic effects of the "Leverage effect", "volatility agglomeration" and "Peak fat tail". These bring heteroscedasticity to the error term. To depict the conditional heteroskedasticity of financial market volatility, Engle first employed the ARCH model in 1982. It assumes that the error term is irrelevant, and its conditional variance depends on the magnitude of previous terms. The expression of the ARCH (q) model is generally written as $\sigma_t^2 = w + a_1 \varepsilon_{t-1}^2 + \dots + a_q \varepsilon_{t-q}^2$, from $t-1$ to $t-q$.

Therefore, The AR-ARCH model incorporates two equations:

$$Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_q Y_{t-q} + \varepsilon_t \quad (1)$$

$$\sigma_t^2 = E(\varepsilon_t^2 | \varepsilon_{t-1}^2 \dots) = \sigma_t^2 = w + a_1 \varepsilon_{t-1}^2 + \dots + a_q \varepsilon_{t-q}^2 \quad (2)$$

Equation (1) is called the mean value equation, while equation (2) is named the ARCH equation.

2.2 Data Selection

In this paper, the daily closing price data of ICBC from January 1, 2018, to June 1, 2021, is taken as the sample data, and the last 10 days' data as the test data, which is from the Tushar database. In this paper, the volatility of the stock market is studied and the daily return of the stock market is taken as a variable. The daily return of the stock market is expressed by the logarithmic first-order difference of the adjacent two-day closing price, R_t is used as the stock daily return on the t day. This makes the daily return to be a time series sample. The detailed values of the return in sequence are shown in Figure 3. As can be seen from the chart of ICBC, its yield fluctuates around the zero means, which can be used to judge that the daily yield of ICBC is stable in the sample period. The stationarity of stock returns is tested by the p-value, which is $1.32e-20$, so the data is generally stable. Moreover, according to the data chart, the rate of return shows the characteristics of time-varying and paroxysm. The volatility of the yield series has the characteristics of persistence and volatility aggregation, and the whole is a stable state. As shown in Figure 4, the ADF test shows that the data gradually converged after step 8. Data is no longer beyond the limit of the point, from this can be seen that the order of the AR model is 8, thus building AR (8) model. The results of at and $\{A2t\}$ mixed test show that the original hypothesis is rejected, there is sequence correlation and ARCH effect. Using the PACF test of $\{at^2\}$ recommend that the paper uses the ARCH (6) model. The diagram of the PACF test is shown in Figure 5.

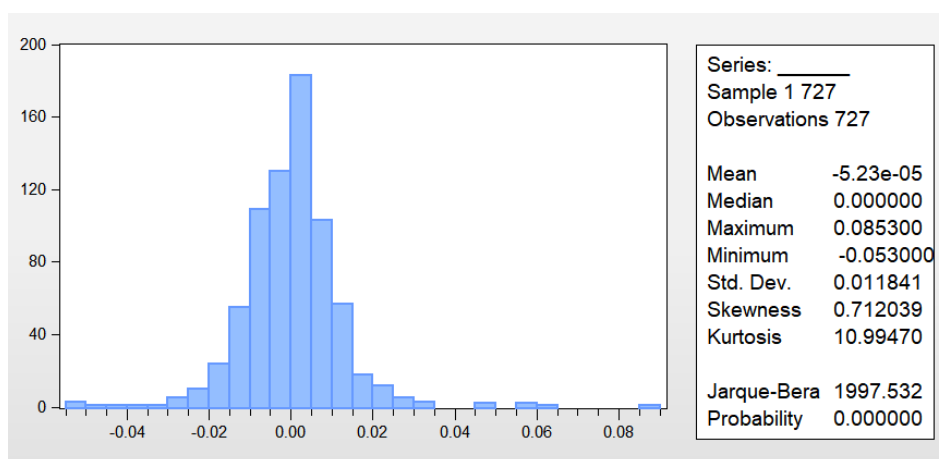


Figure 2. Descriptive statistics.

Table 1. Results of statistics.

Obs.	Mean	Std.	Min	Max	Kurtosis	Skewness
727	-5.23e-05	0.0118	-0.053	0.0853	10.9947	0.7120

From Table 1, it can be seen that the mean is $-5.23e-05$, with a median of 0.5%. The maximum and minimum values are 0.0853 and -0.053, respectively. The standard deviation is 0.011841, and the skewness is 0.712039. It can be seen that the whole data show a right deviation, the peak value is 10.9947, which is much higher than the normal distribution peak value. The rate of return does not follow the normal distribution.

In building an AR model of pure time series, the yield of prediction fitting is not good. It ignores the ARCH effect in the series, and the AR model alone can not deal with the conditional heteroscedasticity of the series. For the series with the ARCH effect, the constant term is not significant if only the volatility is used to model, that is, if only the volatility model is constructed, the mean equation is not significant. Therefore, based on the establishment of the AR mean value

equation, the ARCH model is established for the residual term of mean value to eliminate conditional heteroskedasticity, that is, the AR-ARCH model is established to improve the AR model of sample daily return series.

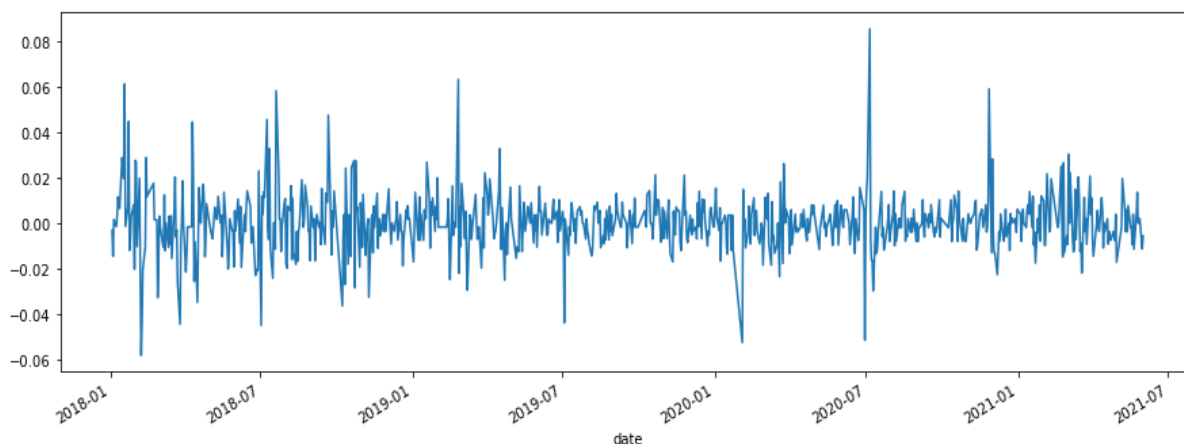


Figure 3. Stock's daily rate of return sequence.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.049	-0.049	1.7677	0.184
		2	0.008	0.005	1.8104	0.404
		3	0.024	0.024	2.2187	0.528
		4	-0.112	-0.110	11.490	0.022
		5	-0.111	-0.124	20.505	0.001
		6	0.007	-0.005	20.540	0.002
		7	-0.029	-0.022	21.150	0.004
		8	-0.093	-0.108	27.548	0.001
		9	0.043	0.004	28.893	0.001
		10	0.010	0.002	28.964	0.001
		11	-0.003	-0.007	28.973	0.002
		12	0.031	-0.001	29.669	0.003
		13	-0.012	-0.028	29.776	0.005
		14	-0.025	-0.022	30.250	0.007
		15	0.006	-0.003	30.274	0.011
		16	-0.023	-0.030	30.667	0.015
		17	-0.003	-0.002	30.673	0.022
		18	0.011	0.002	30.770	0.031
		19	-0.052	-0.059	32.816	0.025

Figure 4. ADF test.

Table 2. Unit root test.

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-28.26868	0.0000
Test critical values		
1% level	-3.439130	
5% level	-2.865305	
10% level	-2.568831	

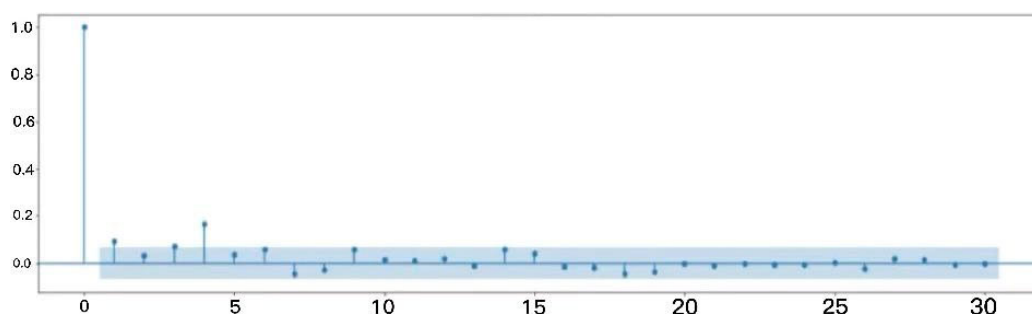


Figure 5. PACF test results of ARCH model.

3. The Empirical Analysis of AR-ARCH Stock Price Forecasting Model

3.1. The Estimated Results of the Model

As shown in Figure 6, the AR-ARCH model can fit the volatility of the return of ICBC's stock price well, which shows that the model can predict the volatility with high accuracy and can reflect the normal volatility, the resulting deviation is small. As shown in Figures 7 and 8, the trend of the stock price return of ICBC predicted by the AR-ARCH model is approximately the same, and the changing trend and the change range of the whole stock price return are not much different from the actual situation. It shows that the model can also predict the yield better, and the model can fit the actual situation.

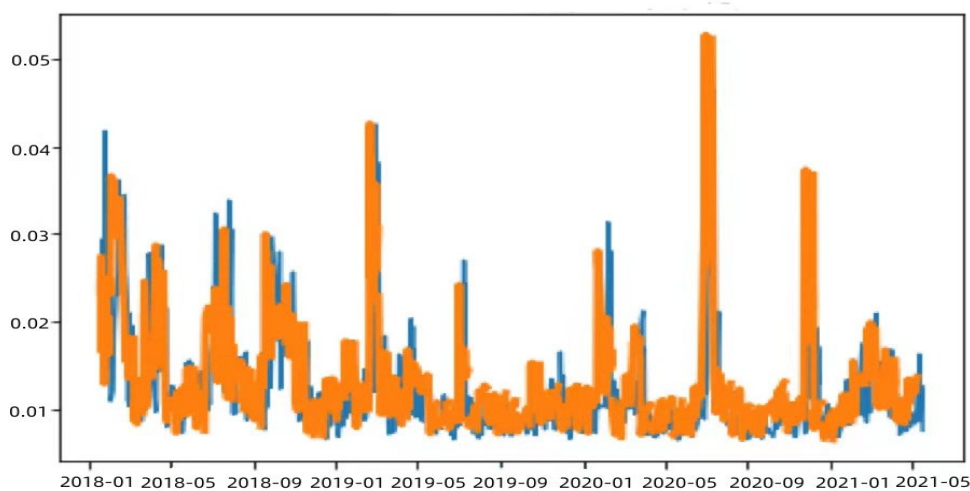


Figure 6. Volatility forecasts.

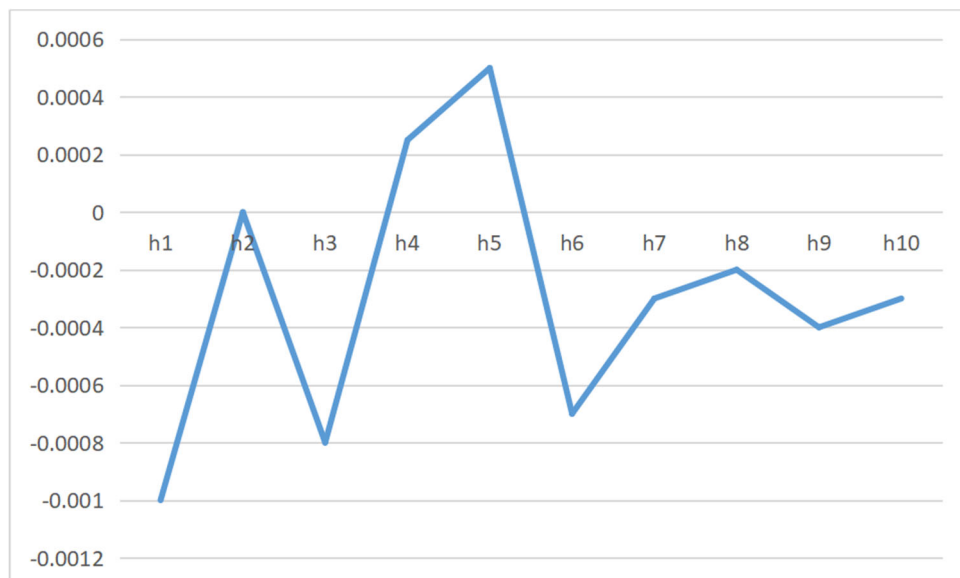


Figure 7. Predict value.

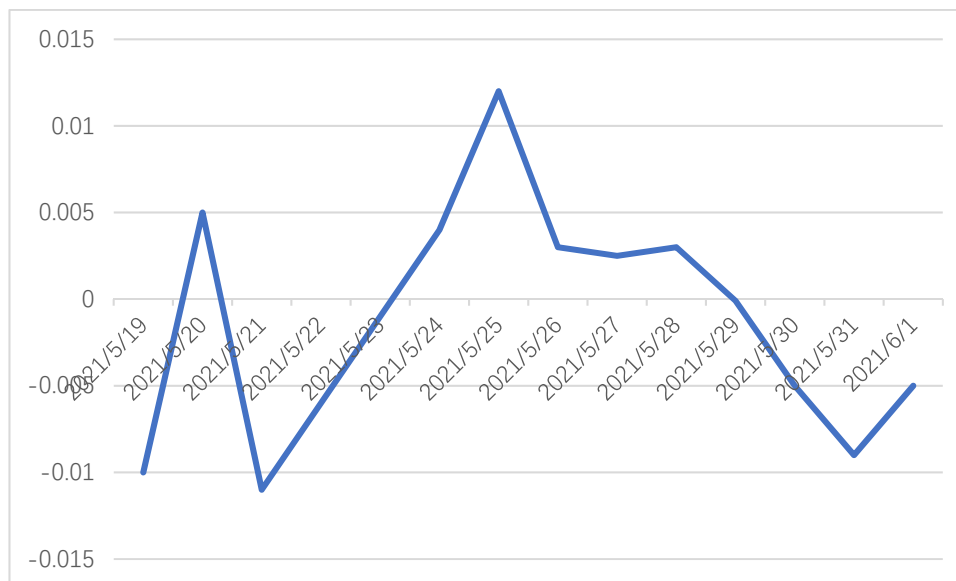


Figure 8. Real value.

3.2. The Results of Empirical Analysis

As shown below, using the six-order autoregressive ARCH model and taking the stock price return data of ICBC as the sample value, the return rate is estimated, and the average model is built as the AR model, the variance model is the ARCH model with adjusted r-square of 0.009. Using the maximum likelihood method, the AIC value is -4946.91 and the BIC value is -4871.48. The average return is -0.013% and the volatility is 0.0041%. With the increase of known information, the accuracy of the ARCH model will be improved obviously. From the theoretical analysis of the ARCH model, it is expected that the prediction accuracy can be improved by increasing the order of self-additive prediction of the ARCH model. After using the ARCH model of high-order regression, the accuracy of prediction can be greatly improved, and the standard deviation of prediction is about 0.04%.

Table 3. AR-ARCH model prediction results.

Panel A: Mean Model (AR)					
	coef	Std err	t	P> t	95.0% Conf.Int.
Const	-1.26e-04	3.40e-04	-0.37	0.71	[-7.92e-04,5.40e-04]
Rate [1]	-2.36e-03	3.83e-02	-6.17e-02	0.95	[-7.74e-02,7.63e-02]
Rate [2]	-3.41e-03	3.62e-02	-9.43e-02	0.93	[-7.43e-02,6.75e-02]
Rate [3]	0.041	4.07e-02	1.02	0.31	[-3.84e-02,0.12]
Rate [4]	-0.036	3.95e-02	-0.91	0.37	[-0.11,4.17e-02]
Rate [5]	-0.11	4.05e-02	-2.73	6.33e-03	[-0.19,-3.12e-02]
Rate [6]	0.079	5.36e-02	1.47	0.14	[-2.64e-02,0.18]
Rate [7]	0.060	4.20e-02	1.42	0.16	[-2.26e-02,0.14]
Rate [8]	-0.038	3.34e-02	-1.13	0.26	[-0.10,2.76e-02]
Panel B: Volatility Model (ARCH)					
	coef	Std err	t	P> t	95.0% Conf.Int.
omega	4.06e-05	5.53e-06	7.34	2.18e-13	[2.97e-05,5.14e-05]
Alpha [1]	0.073	5.20e-02	1.40	0.16	[2.90e-02,0.18]
Alpha [2]	0.012	1.89e-02	0.62	0.59	[-2.55e-02,4.87e-02]
Alpha [3]	0.051	3.43e-02	1.48	0.14	[-1.63e-02,0.12]
Alpha [4]	0.37	0.14	2.61	9.16e-03	[9.25e-02,0.65]
Alpha [5]	0.057	4.50e-02	1.26	0.21	[-3.14e-02,0.15]
Alpha [6]	0.29	0.12	2.39	1.68e-02	[5.29e-02,0.53]

4. Conclusions

Due to the rapid development of the stock market, it could be affected by various factors and participants' actions. Quasi-irregular volatility contributes to a high level of risk, which suggests that a reasonable stock price forecast is particularly important. Being able to reasonably predict stock price movements can reduce the risk of market volatility and make investments more stable, which also plays an important role in maintaining financial stability. Based on the above points, this paper uses the new forecast model to select the daily closing price of ICBC's stock from January 1, 2018, to June 1, 2021. First, the stationarity of stock returns is tested and then the mean-value equation AR model is constructed by the PACF test. Through Arch Effect Test and PACF test, the variance equation ARCH equation is constructed, and thus the AR-ARCH model is constructed. Finally, the volatility and return of the stock price fit the overall situation of the forecast.

The stationarity test is used to determine whether the data are stable, and the PACF test is used to determine the correlation between the data and the existence of the unit root. Then the AR model of the mean value equation is established to predict the data simply. On this basis, the mean value equation AR model is established to predict the data, and the variance equation Arch equation is established through the ARCH effect test and PACF test, then the AR-ARCH model is established. Based on a lot of analysis, the last conclusion is drawn: the fluctuation and regression are following the forecast. The whole experiment is carried out step by step, with high rigor and accuracy, and accurate conclusions can be drawn.

By using the forecasting method of time series analysis, this paper empirically analyses the daily stock return series of ICBC. The improved AR-ARCH model can fit and forecast the daily stock return series of ICBC. The simulation results of volatility and return are good. Although AR-ARCH can predict the future stock price, the predictions and the reality still have a relatively large gap. This is due to the relatively undeveloped level of China's stock market at present. Besides, short-term national economic conditions, macroeconomic policy, investors' psychological expectations, and many other factors will contribute to the fluctuation of stock prices to some extent. Therefore, in the future, it suggests including as many dependent variables as possible into consideration, such as the fundamentals of operating enterprises, technical indicators, and so on, to achieve the maximum return or get the lowest risk of investment objectives.

The study of forecasting stock prices is highly related to the importance of the stock market in this country. When the economy and needs for financing from shares improve, the study and the forecasting methods will develop and progress. This improvement will cause a more precise prediction and a further application to the other aspects, thus helping scholars and investors figure out the leading factors of the moving share prices.

After the fitting results of the AR-ARCH model are obtained, the next step is to consider how to further optimize the results of such a fitting, or how to use other models to make the prediction results more accurate. Compared with other countries, the stock market of our country and the factors that affect the stock market are more complicated. Many factors need to be controlled, the data inside and outside the sample are analyzed, and the ARMA model is used to solve the white noise problem, which makes the model more stable and accurate to predict the data inside and outside the sample. Risk in the stock market and a range of financial markets can be better mitigated based on forecasts, which can be used to promote further development of the market. The model applied in the essay is just a tool for data analysis and prediction. Different models have different particularities, and different data need to find the most suitable model for analysis. The analysis and comparison of various models can better and more effectively solve financial problems.

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