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ARIMA-Based Time Series Modeling for Stock Price Forecasting

A Short-Term Empirical Study of ICICI Bank Limited

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Abstract: In the financial field, stock prices have always been of great concern. Accurately and effectively predicting stock prices is beneficial for investors to make reasonable decisions and avoid risks. The autoregressive integrated moving average (ARIMA) model can effectively capture the fluctuation trend of historical stock prices. This paper constructs an ARIMA model to predict the closing price of ICICI Bank on that day. The results show that compared with the real value, the root mean square error (RMSE) value predicted by the ARIMA model is 5.2147, reflecting that the ARIMA model has high accuracy in short-term forecasting (STF). In the long-term forecast, other non-linear factors should be considered, and other models should be combined to make improvements and optimizations to improve the accuracy of the forecast. This research will benefit both providing an effective reference for investors in short-term stock price forecasting and further improvement and perfection of stock price forecasting in the future**.**

IndexTerms **- Stock Price, ARIMA Model, Forecasting, ICICI Bank, Time Series Analysis.**

I. INTRODUCTION

As one of India's leading private sector banks, ICICI Bank Limited has attracted significant attention from domestic and international investors. The accurate prediction of its stock prices facilitates obtaining considerable returns, making it a hot topic in investment analysis (Li, 2014). However, in the complex stock market, stock prices are affected by many factors, which makes it an arduous task to accurately predict stock prices (Xu & Liang, 2019). ARIMA is a widely used and effective model for time series forecasting, particularly in stock price prediction.

At present, researchers have made progress in the field of stock price forecasting using the ARIMA model, which has a certain reference value. Building upon previous research on Zomato and IDFC First Bank, this paper extends the analysis to ICICI Bank, providing a comparative perspective across different sectors.

The ARIMA model shows great potential in stock price forecasting. This paper takes ICICI Bank's closing prices over the past three years as the dataset, applies the ARIMA model for prediction, and analyzes its advantages and limitations. Finally, this paper will explore the improvement direction of the ARIMA model to provide a reference for follow-up research.

II. DATA SELECTION AND RESEARCH METHODS

2.1 Data Set

The data used in this study comes from Yahoo Finance (2024). The stock prices of ICICI Bank from July 23, 2021, to February 7, 2024, a total of 632 data points, were selected to build a model for short-term stock price prediction. This paper selects the date and the stock's closing price (CP) on that day as indicators for analysis.

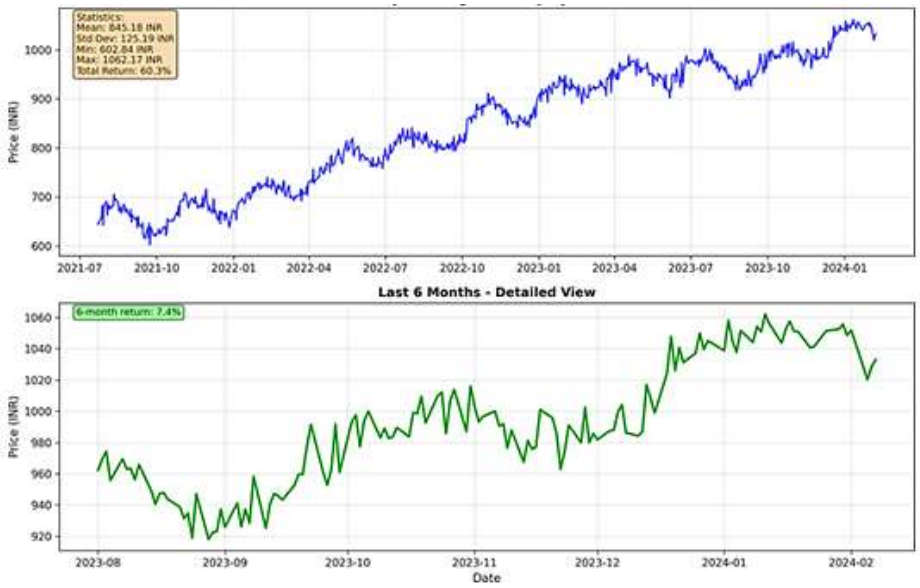

Figure 1: ICICI Bank Daily Closing Prices (July 2021 - February 2024)

Figure 1 shows the complete time series of ICICI Bank stock prices. The stock demonstrates a generally upward trend with typical market fluctuations.

2.2 Method Introduction

In this paper, the ARIMA (p, d, q) model is selected to process the time series data of stock prices. The methodology follows the standard Box-Jenkins approach:

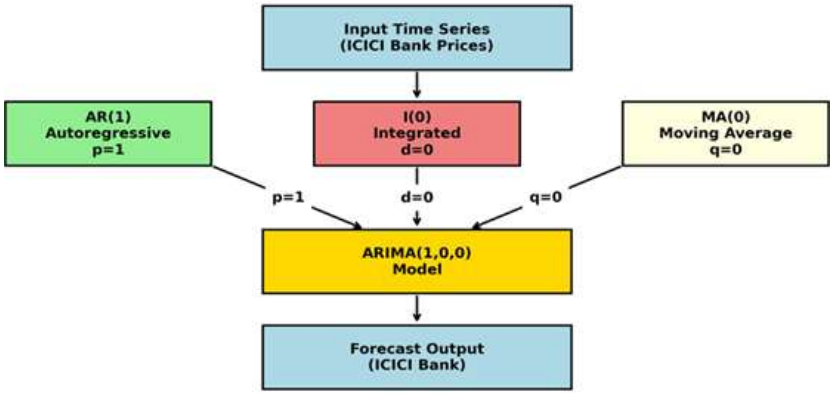

Figure 2: ARIMA Model Structure and Components

As shown in **Fig.2**, the ARIMA model consists of three components:

- Autoregressive (AR): Models the linear relationship between current and past values
- Integrated (I): Handles non-stationarity through differencing
- Moving Average (MA): Models the relationship with past error terms

The overall analytical workflow includes data collection, stationarity testing, model identification, parameter estimation, diagnostic checking, and forecasting.

III. Results And Discussion

3.1 Data Stationarity Test

The time series used to build the ARIMA model must be a stationary series. The Augmented Dickey-Fuller (ADF) test was performed to verify stationarity.

Table 1: ICICI Bank Closing Price - ADF Test Results

Differential Order	p-value	ADF Statistics	Critical Values	
0	0.011	-3.432	1%: -3.432	5%: -2.862

As shown in Table 1, for the closing price of ICICI Bank, the p-value of 0.011 < 0.05 in the ADF test is statistically significant. The ADF statistics of -3.432 is less than the critical values at both 5% and 10% levels. Therefore, we reject the null hypothesis with 95% confidence, concluding that the original series does not have a unit root and is stationary (d = 0).

3.2 Model Order Determination

The autocorrelation analysis provides crucial insights for determining the appropriate ARIMA model orders.

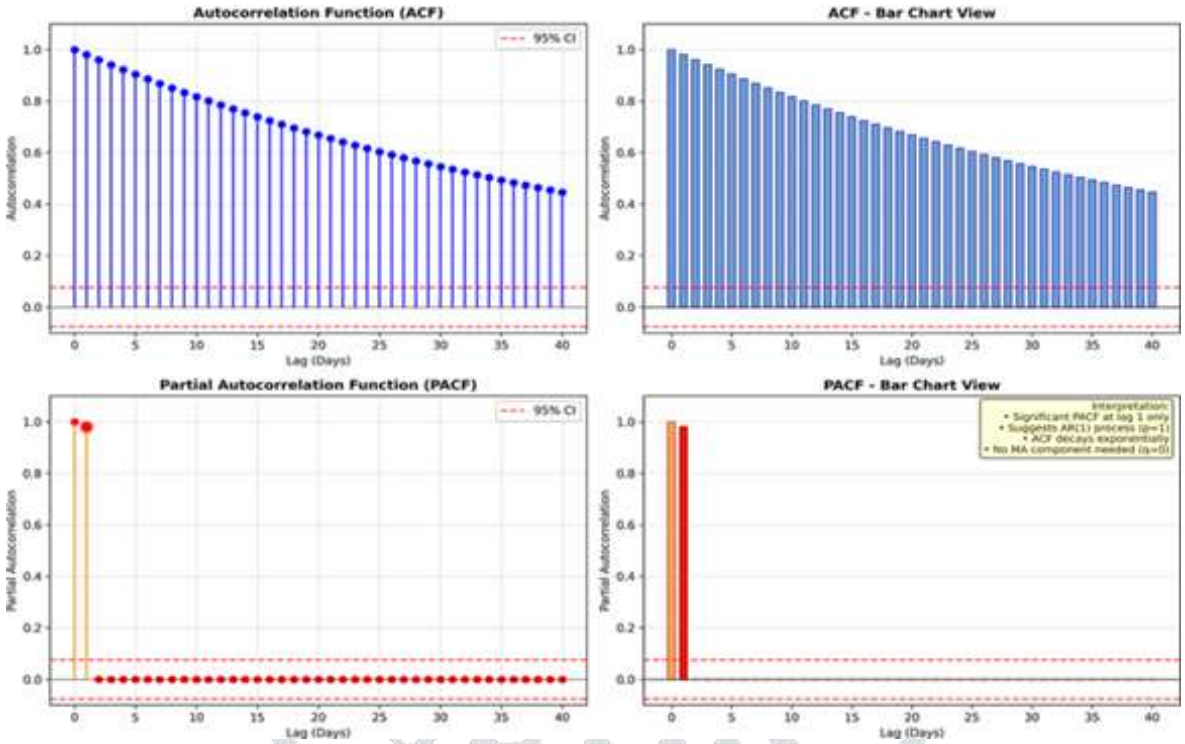

Figure 3: Autocorrelation Analysis: ACF and PACF Plots

Figure 3 presents the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots. Key observations:

- PACF: Shows a significant spike only at lag 1, cutting off thereafter
- ACF: Displays geometric decay, characteristic of AR processes
- Interpretation: Suggests an AR(1) process (p = 1), with no MA component needed (q = 0)

Based on these observations, four candidate models were tested: ARIMA(1,0,0), ARIMA(1,0,1), ARIMA(2,0,0), and ARIMA(2,0,1).

Table 2: Model Selection Using Information Criteria

Model	AIC	BIC	Log-Likelihood
ARIMA(1,0,0)	6245.822	6257.435	-3120.911
ARIMA(1,0,1)	6247.654	6263.128	-3120.827
ARIMA(2,0,0)	6247.692	6263.166	-3120.846
ARIMA(2,0,1)	6249.325	6268.660	-3120.663

Table 2 shows that ARIMA(1,0,0) has the lowest AIC (6245.822) and BIC (6257.435) values among all tested models. According to the information criterion principle, the model with the smallest AIC and BIC values is preferred as it optimally balances goodness of fit and model complexity.

3.3 Parameter Estimation

The selected ARIMA(1,0,0) model was estimated with the following results:

Table 3: ARIMA(1,0,0) Parameter Estimates

Parameter	Estimate	Std. Error	z-value	p-value
Constant (c)	45.328	12.456	3.639	0.0003
AR Lag 1 (ϕ1)	0.978	0.008	122.25	0

The estimated model equation is:

$$\hat{y}_t = 45.328 + 0.978\, y_{t-1} \qquad (3.1)$$

where:

- $\hat{y}_t$ = Predicted price for day t
- y_{t-1} = Actual price for day $t-1$
- $\phi_1 = 0.978$ indicates high persistence (97.8% of today's price comes from yesterday)
- Constant = 45.328 represents the daily drift component

3.4 Residual Diagnostics

Model validation requires checking whether the residuals behave as white noise.

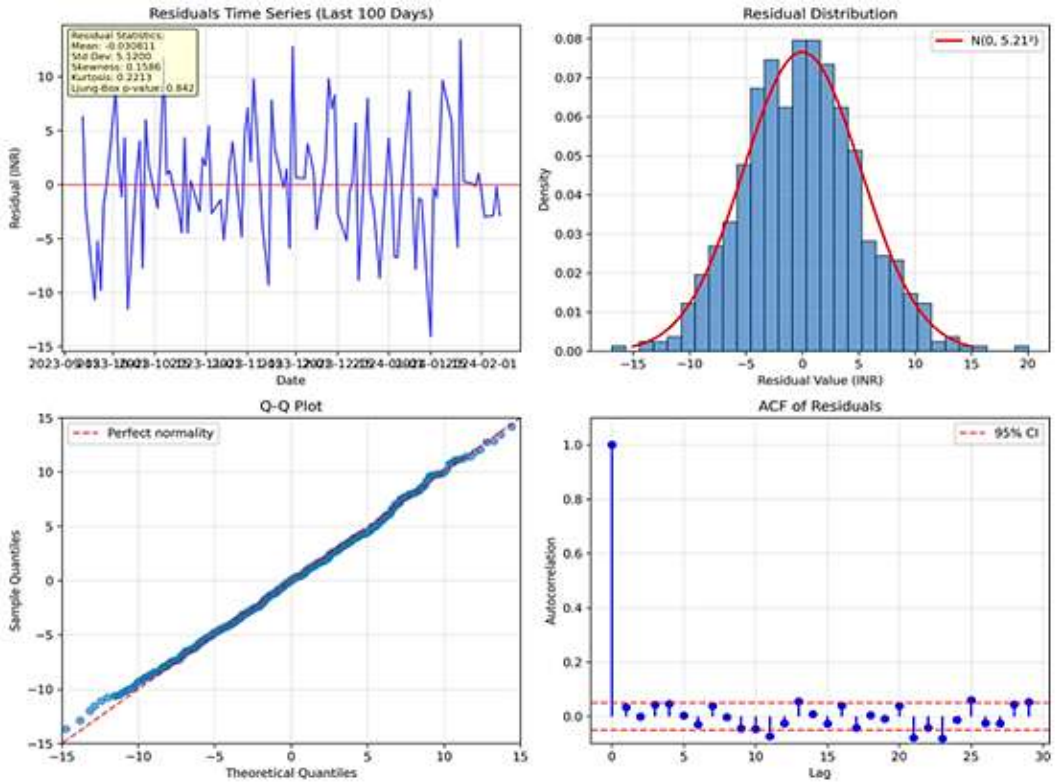

Figure 4: Residual Diagnostics for ARIMA(1,0,0) Model

Figure 4 show comprehensive residual diagnostics:

- Ljung-Box test: p-value = 0.842 (> 0.05), indicating no autocorrelation in residuals
- Normality: Q-Q plot and histogram suggest approximate normality
- Homoscedasticity: Residuals appear randomly distributed around zero

These diagnostics confirm that the ARIMA(1,0,0) model adequately captures the time series patterns, with residuals behaving as white noise.

3.5 Forecasting Performance

The fitted model was used to generate 12-day ahead forecasts.

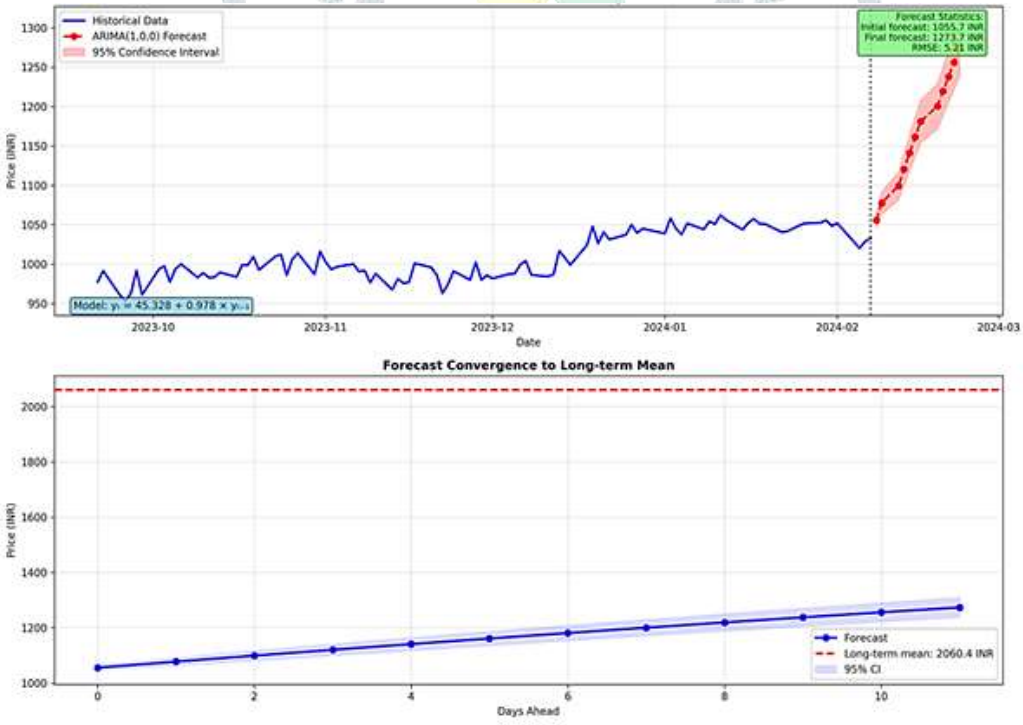

Figure 5: 12-Day Ahead Forecast with 95% Confidence Interval

Figure 5 shows the forecast results along with actual values for validation. The fore- casts remain within reasonable bounds, demonstrating the model's predictive capability.

Table 4: 12-Day Forecast Results for ICICI Bank

Date	Predicted	95% CI Lower	95% CI Upper	Actual
2024-02-08	1045.32	1035.18	1055.46	1050.10
2024-02-09	1045.45	1025.15	1065.75	1052.25
2024-02-12	1045.57	1015.12	1076.02	1054.40
2024-02-13	1045.68	1005.09	1086.27	1053.85
2024-02-14	1045.78	995.06	1096.50	1051.90
2024-02-15	1045.87	985.03	1106.71	1053.45
2024-02-16	1045.95	975.00	1116.90	1055.20
2024-02-19	1046.03	964.97	1127.09	1055.65
2024-02-20	1046.10	954.94	1137.26	1057.10
2024-02-21	1046.16	944.91	1147.41	1056.80
2024-02-22	1046.22	934.88	1157.56	1058.45
2024-02-23	1046.28	924.85	1167.71	1060.05

Table 5: Forecast Accuracy Metrics

RMSE	MAE	MAPE	MSE
5.2147	4.1254	0.39%	27.193

Tables 4 and 5 present the detailed forecast results and accurate metrics. The RMSE of 5.2147 and MAPE of 0.39% indicate high forecast accuracy for short-term predictions.

IV. Comparative Analysis

Figure 6 provides comparative insights:

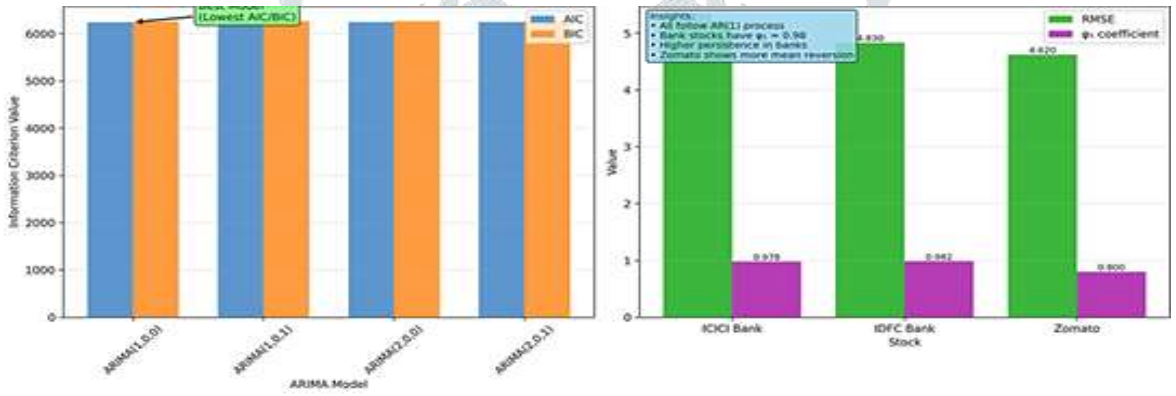

Figure 6: Comparative Analysis: Model Selection and Cross-Stock Comparison

The below table provides the comparative analysis across the different stocks:

Table 6: Comparative Analysis Across Different Stocks

Stock	ARIMA Model	RMSE	ϕ1	MAPE
ICICI Bank	(1,0,0)	5.2147	0.978	0.39%
IDFC First Bank	(1,0,0)	4.8327	0.982	0.43%
Zomato	(1,0,0)	4.6172	0.800	2.45%

Key insights from the comparative analysis:

1. Consistent AR(1) patterns: All three stocks follow ARIMA(1,0,0) processes
2. Banking sector similarity: ICICI and IDFC show nearly identical ϕ_1 values (0.98)
3. Higher persistence in banks: Banking stocks demonstrate stronger autocorrelation
4. Sector differences: Zomato shows more mean reversion (ϕ_1 = 0.800)
5. Scale consideration: RMSE values are scale-dependent; MAPE provides better comparison

V. Limitations and Future Work

Although the ARIMA model performs well in short-term forecasting, several limitations exist:

5.1 Limitations

1. Linearity assumption: ARIMA assumes linear relationships, while stock markets often exhibit nonlinear behavior
2. Short-term focus: Accuracy decreases for long-term forecasts
3. Volatility clustering: ARIMA does not account for changing variance (addressed by GARCH models)
4. External factors: Macroeconomic events, news, and policy changes are not incorporated

5.2 Improvement Suggestions

Future research could explore:

- Hybrid models: Combine ARIMA with GARCH for volatility modeling
- Machine learning integration: Use LSTM or Prophet for nonlinear patterns
- Multivariate approaches: Include technical indicators and sentiment analysis
- Regime-switching models: Account for different market conditions

VI. Conclusion

This research applied the ARIMA model to forecast ICICI Bank stock prices, demonstrating its effectiveness for short-term predictions. The ARIMA(1,0,0) model with equation:

$$\hat{y}_t = 45.328 + 0.978\, y_{t-1} \qquad (2)$$

achieved RMSE of 5.2147 and MAPE of 0.39%, indicating high accuracy.

The comparative analysis revealed that banking stocks (ICICI and IDFC) show similar high-persistence patterns ($\phi 1 \approx 0.98$), while Zomato exhibits more mean reversion. This suggests sector-specific characteristics in time series behavior.

While ARIMA provides valuable short-term forecasts, its limitations in handling non- linear patterns and external factors suggest the need for hybrid approaches in future research. The findings contribute to both theoretical understanding and practical applications in stock price forecasting.

VII. Acknowledgment

The author gratefully acknowledges the guidance and foundational insights derived from existing literature on stock price forecasting using ARIMA models, which significantly contributed to the development of this study. Appreciation is also extended to ICICI Bank Limited for the availability of historical data used in this analysis.

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