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Investigating the Efficacy of ARIMA Models for Predicting Dow Jones Industrial Average Stock Prices

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Abstract

The prediction of stock price volatility holds significant importance in the realms of economics and finance, offering substantial benefits to both investors and economists. This paper employs the Autoregressive Integrated Moving Average (ARIMA) model to forecast the stock prices of the Dow Jones Industrial Average (DJI), a key index in the financial market. The study utliises daily data of the Dow Jones Industrial Average (DJI) spanning from 1 April 2021 to 31 March 2023. Empirical evidence strongly suggests the effectiveness of ARIMA models in predicting DJI stock prices. Furthermore, the study's findings reveal that the ARIMA model excels particularly in short-term forecasting, demonstrating favourable performance when compared to existing techniques for stock price prediction. Through the utilisation of the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) criteria, the study identifies ARIMA (1, 1, 0) as the optimal model for accurately forecasting the share price of DJI within the specified timeframe.

Keywords: ARIMA Model, Dow Jones Industrial Average (DJI), USA, Stationarity

Introduction

Predicting the future performance of stock prices has become a popular topic for many individuals, as institutions are placing increased emphasis on decision making and strategising for future work. The emphasis on predicting results is motivated by the understanding that the ability to anticipate future events can have a significant impact on decision-making and enable the development of effective strategies for achieving success (Afeef et al., 2018). Researchers in the field of stock prediction are constantly exploring and experimenting with new strategy to improve their future growth. This is because institutions and individuals need reliable predictions to make informed investment decisions and develop effective strategies for their present and future activities (Khandelwal et al., 2021).

ARIMA Model

The Autoregressive Integrated Moving Average (ARIMA) model is a statistical technique used to analyse and predict stock price by examining the relationships within the data (Wadi et al., 2021). The ARIMA model, also known as Box-Jenkins methodology, is structured with three parameters: p, d and q, which represent autoregressive, differencing and moving average terms, respectively. The autoregressive terms capture the relationship between current and lagged observations, while differencing removes trends and seasonality. The moving average terms capture the dependence on lagged residual errors. The model is denoted as ARIMA (p, d and q) and selecting the appropriate parameter values is crucial for accurate forecasting. The determination of optimal values is typically done through data analysis and model evaluation techniques like AIC or BIC.

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Literature Review

Shao (2023) investigates the potential of utilising the ARIMA model to predict the adjusted closing stock price trend of Moderna, particularly focusing on the unique context of the pandemic. By referencing academic literature and employing statistical techniques such as differencing and assessing stationarity, the study concludes that the ARIMA model is an effective tool for analysing Moderna's stock trend. It acknowledges the model's limitations and proposes future directions for research. Ultimately, based on parameter selection and analysis, the study suggests that the ARIMA [4, 1, 2] model provides an appropriate forecast for Moderna's adjusted closing stock trend within the given dataset limitations. Bansal et al. (2022) introduces an integrated model combining ARIMA, LSTM and Prophet Model for stock market prediction, demonstrating superior performance over individual models. The integrated model was validated with a simulation using random stock price data, showcasing its predictive accuracy. Results, illustrated in a Google Colab snapshot, confirm the model's effectiveness in predicting future stock prices. Through tables and trend line snapshots, the study asserts the integrated model's superiority, providing a successful solution for stock market trend prediction. Garlapati et al. (2021) analysed stock market trends and patterns of data to forecast future stock prices using ARIMA and Facebook Prophet Models and the Mean Absolute Percentage Error is used to evaluate their forecasting accuracy. The study found that the ARIMA (2, 1, and 2) model is best for predicting stock prices. Additionally, Facebook Prophet is used to demonstrate future forecasting of stock prices. And found that it has potential for further investigation in the future. Wadi et al. (2021) used the ARIMA model to predict closed time series data from the Amman Stock Exchange, researchers found that the model was effective in making short-term predictions. The study suggests that these findings could be helpful for investors looking to make informed investment decisions based on the data. Zhanao et al. (2020) explored the application of ARIMA and ETS models on the S&P500 index's close price data and determined the accuracy of the models, specifically using the quantmod package in R Studio. The forecasting results indicate that the ARIMA model provides a better fit with the data and shows promising predictions of the general trend compared to other existing methods. Islam et al. (2020), Khan et al. (2020) examined the application of various ARIMA models for accurate forecasting of stock prices using five years of historical data from Netflix. With the comparison of auto ARIMA and two customised ARIMA models and found that ARIMA (1, 1 and 33) demonstrated the highest accuracy in terms of calculating the Mean Absolute Percentage Error and performing holdout testing.

Statement of the Problem

Many researchers have made predictions about stock prices using a various linear and non-linear models. However, the findings of these studies have been inconsistent. This study aims to investigate the significance of predicting stock prices using the ARIMA model and the strategies employed by investors to forecast future prices of Dow Jones Industrial Average (DJI). The study emphasises that researchers commonly consider various factors that influence the worth and profitability of stock exchange of USA when making these predictions.

Objective of the Study

To forecast the stock prices of DJI using ARIMA model.

Research Methodology

The study employ ARIMA model to forecast stock prices of DJI. The process involves developing customised ARIMA (p, d, q) models to enhance the accuracy of the predictions. The study concentrates on the daily stock price index of DJI, specifically from 1 April 2021 to 31 March 2023, obtained from the respective stock exchange. The normality of the data has been assessed using the Augmented Dickey Fuller (ADF). The selection of the optimal ARIMA model has based on lower ACF and PACF values as the evaluation criteria. The statistical tools utilised for the analysis have been EViews version 12.0 and Microsoft Excel.

Result and Discussion

Stationarity Test

Table 1: Unit Root Analysis using ADF at the Level

Sr. No.	Variable	T-Statistic	ADF	Critical Value at 1%	Critical Value at 5%	Critical Value at 10%
1.	DJI	-2.3916	0.1446	-3.443123	-2.867066	-2.569775

Table 2: Unit Root Analysis using ADF at 1st Difference

Sr. No.	Variable	T-Statistic	ADF	Critical Value at 1%	Critical Value at 5%	Critical Value at 10%
1.	DJI	-22.1805	0.0000	-3.443123	-2.867066	-2.569775

According to Tables 1 and 2, the ADF test has been utilised to assess the stationarity of the data. To ensure accurate and valid results, DJI has been transformed into logarithmic values before conducting the ADF test. This has been necessary because the original continuous data has not been normalised. The conversion to logarithmic values has helped in achieving a normal distribution of the data. The results of the ADF test indicate that DJI has exhibited stationarity after taking the 1st difference.

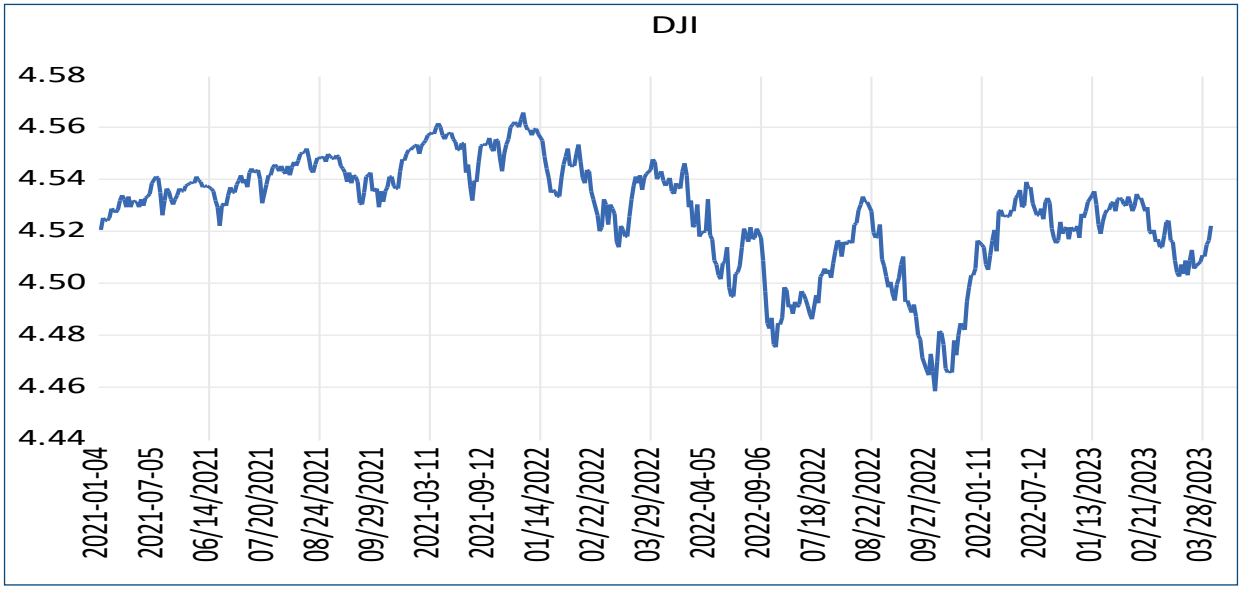

Fig. 1: DJI Figure (Non-Stationary)

According to Fig. 1, it has become evident that the DJI has exhibited a unit root due to the presence of a discernible trend. As a result, the data can be classified as non-stationary.

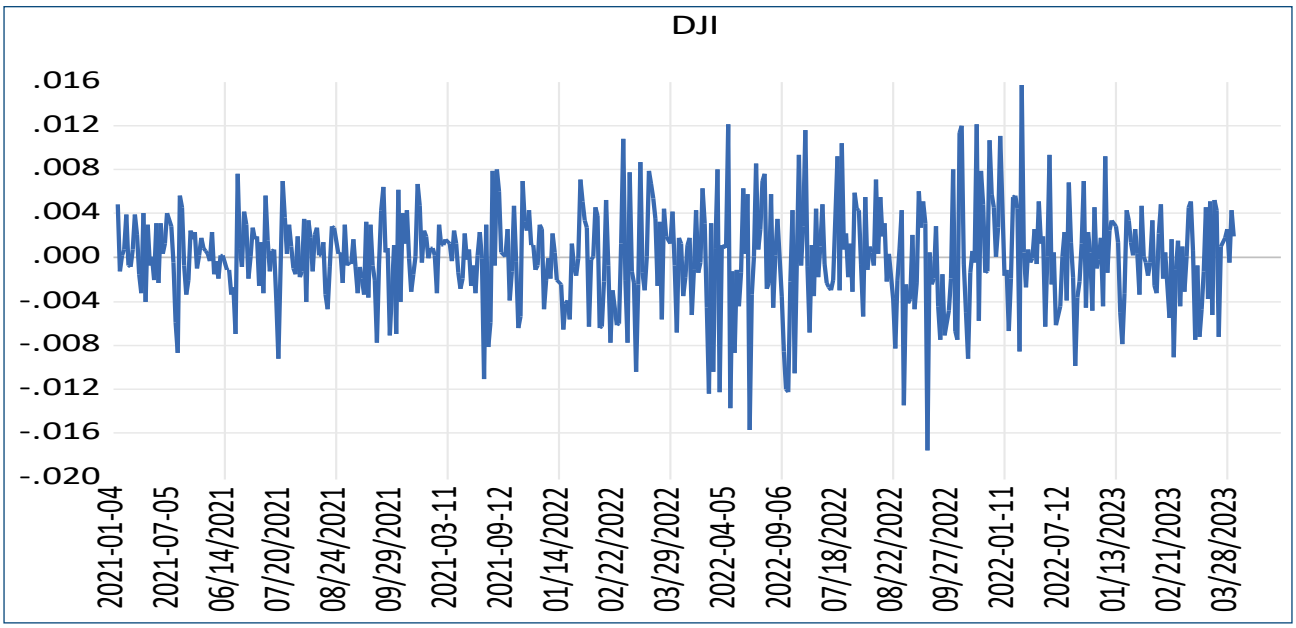

Fig. 2: DJI Figure at 1st Difference

According to Fig. 2 the absence of a discernible trend in the DJI suggests that it has not exhibited a unit root, indicating that the data has been stationary.

Table 3: DJI Correlogram Test

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.475	-0.475	113.62	0.000
		2	-0.026	-0.325	113.98	0.000
		3	-0.012	-0.264	114.05	0.000
		4	0.009	-0.215	114.09	0.000
		5	0.016	-0.158	114.22	0.000
		6	-0.037	-0.181	114.90	0.000
		7	0.046	-0.115	115.98	0.000
		8	-0.054	-0.165	117.47	0.000
		9	0.086	-0.046	121.31	0.000
		10	-0.090	-0.118	125.42	0.000
		11	0.071	-0.036	127.98	0.000
		12	-0.074	-0.114	130.80	0.000
		13	0.075	-0.029	133.69	0.000
		14	-0.039	-0.049	134.47	0.000
		15	-0.016	-0.070	134.60	0.000
		16	0.029	-0.057	135.03	0.000
		17	-0.042	-0.104	135.96	0.000
		18	0.083	-0.018	139.51	0.000
		19	-0.088	-0.080	143.56	0.000
		20	0.056	-0.052	145.18	0.000

According to Table 3, the data used in the study has been determined to be stationary after applying the first difference (differencing the data once). A correlogram test has been conducted to determine the values of p and q. The test results indicate that there has been no autocorrelation at lag 1, and the spikes in partial autocorrelation have exceeded the standard error in DJI. As a result, the initial ARIMA model that has been considered for further

analysis is ARIMA (1, 1, and 1) for DJI. Based on this model, three potential models can have been created: (1,1,1), (0,1,1) and (1,1,0). These models can be evaluated to determine the best fitted model.

Table 4: Coefficient of Different Models

	1,1,1	*0,1,1*	*1,1,0*
Significant coefficient	0	0	1
SIGNASQ	2.064946	2.0651	3.159798
Adjusted R-squared	0.494264	0.2230173	0.4921994
AIC	-7.92165	-7.51207	-7.92552
BIC	-7.88804	-7.48686	-7.90031

To choose the most suitable model for the DJI, the coefficients of various models have considered. The AIC and BIC values have been chosen based on their lowest values. Among the three estimated ARIMA models, the best one for DJI has been found to be (1, 1, 0), with AIC and BIC values of -7.92552 and -7.90031, respectively.

Forecasting of Share Prices

Table 5: Actual and Predicted Share Price of DJI

Date	*Actual*	*Predicted*
04-03-2023	33,600.92	33.277.08
04-04-2023	33,403.04	33277.33
04-05-2023	33,482.59	33277.59
04-06-2023	33,485.35	33277.84
04-10-2023	33,585.93	33278.09
04-11-2023	33,685.12	33278.34
04-12-2023	33,647.22	33278.59
04/13/2023	34,030.34	33278.85
04/14/2023	33,885.31	33.279.10
04/17/2023	33,987.37	33279.35
04/18/2023	33,976.53	33279.60
04/19/2023	33,897.34	33279.86
04/20/2023	33,788.27	33280.11
04/21/2023	33,809.03	33280.36
04/24/2023	33,875.92	33280.61
04/25/2023	33,531.72	33280.87
04/26/2023	33,301.67	33281.12
04/27/2023	33,826.66	33281.37
04/28/2023	34,098.95	33281.62

Table 5 has shown actual and forecasted share prices of DJI on different dates. For instance, on 3 April 2023, the observed price has been 33,600.92, while the predicted value has been 33,277.08. Similarly, on April 4, the recorded price has stood at 33,403.04, with a predicted price of 33,277.33. This trend has continued for subsequent dates. The table has illustrated that the projected prices generally have fluctuated with slight variances. Whereas the actual price has been significantly deviated from the predicted range. Overall, the analysis suggests that the forecasting model used has demonstrated reasonable accuracy in predicting DJI prices, although it may not have captured all market fluctuations with precision.

Conclusion

This research employed the effectiveness of the ARIMA method in predicting future stock prices. Through various experiments conducted in this study, it was determined that the ARIMA (1, 1, 0) model is the most suitable for forecasting the DJI due to its low AIC and BIC value. However, it should be noted that external and internal factors have a significant impact on stock price movements. Investor expectations can greatly influence and shape changes in stock prices. Additionally, rising stock prices indicate investor confidence in listed companies, making their stocks desirable for potential buyers. Furthermore, improvements in economic fundamentals also contribute to the upward movement of stock prices.

To further enhance this research, it is necessary to address certain limitations. This includes expanding the data sample to cover a longer time period to capture more comprehensive insights. Such an expansion may potentially alter the choice of the appropriate ARIMA model. Hence, future research can focus on expanding the data sample to cover a longer period. Furthermore, it would be beneficial to utilise a larger data sample and include additional indices in subsequent studies. Financial institutions can also leverage the ARIMA (1, 1, 0) forecasts in their strategic planning processes. Incorporating these forecasts can assist in devising trading strategies, conducting risk assessments and overall asset management strategies based on the predicted DJI prices. The model's effectiveness in short-term forecasting is particularly valuable during volatile market conditions, as it helps institutions adapt their strategies to the dynamic

market trends. Additionally, regulators and policymakers can use the study's insights to better understand market dynamics and potential impacts of policy changes on stock prices. This knowledge can inform policy discussions surrounding market stability, investor protection and overall market efficiency.

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