Time Series Analysis of IT Stocks:

Examining the Relationship Between Infosys, TCS, and NIFTY IT Index

UHD MSDA Program

Group: 8

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Abstract

The present study aims to analyse the time-series relationships among two prominent Indian IT stocks, INFOSYS and TCS, and the NIFTY IT Index, and to forecast future stock prices. Using daily stock data from January 1, 2015, to December 31, 2015. The study employs advanced time-series techniques, including stationarity checks, autocorrelation, and cross-correlation analysis. Following the Box-Jenkins methodology, ARIMA and SARIMA models were fitted using maximum likelihood estimation to capture trends and seasonality in the data.

The results indicate that the ARIMA (1,0,0) model provides the best fit for the original series of NIFTY IT Index, TCS, and INFOSYS, while auto. Arima () suggested alternative models. Comparative analysis reveals that the manually selected ARIMA (1,0,0) model balances simplicity and predictive accuracy, making it suitable for forecasting. Future projections suggest stable growth in stock prices, highlighting the influence of the NIFTY IT Index on individual stock performance.

These findings offer valuable insights for investors and policymakers, emphasizing the importance of market indices in shaping stock performance. By understanding these dynamics, stakeholders can make informed decisions and adapt strategies in response to evolving market trends.

Introduction

India's IT sector has been a cornerstone of the nation's economic growth, with major companies like INFOSYS and TCS contributing significantly to market trends. The NIFTY IT Index, which reflects the performance of the Indian IT sector, serves as a critical benchmark for understanding these trends. As globalization continues to shape markets, understanding the relationships between major stocks and sector indices has become vital for investors and policymakers alike.

In recent years, the Indian IT sector has witnessed unprecedented growth, driven by technological advancements, digital transformation initiatives, and increasing demand for IT services globally. This growth necessitates a robust understanding of stock market dynamics, enabling stakeholders to anticipate future trends and make informed decisions. INFOSYS and TCS, two of the most prominent players in the sector, provide a unique opportunity to explore these dynamics in detail.

The present study aims to analyse the time-series relationships among INFOSYS, TCS, and the NIFTY IT Index, focusing on identifying models that best fit the data and forecasting future stock prices. Using daily stock data from January 1, 2015, to December 31, 2015, the study employs the Box-Jenkins methodology, including stationarity checks, autocorrelation and cross-correlation analysis, and ARIMA/SARIMA modelling. These techniques will help uncover the influence of the NIFTY IT Index on individual stocks and provide insights into the predictive capabilities of time-series models.

The findings of this study are expected to assist investors in understanding stock performance within the IT sector and offer policymakers a foundation for addressing market trends effectively. By forecasting stock prices and examining the interplay between market indices and individual stocks, this research aims to contribute to the broader discourse on financial market analysis and strategic decision-making.

Purpose

The primary purpose of this project is to investigate the time-series relationships among INFOSYS, TCS, and the NIFTY IT Index to understand how market trends influence individual stock performance and forecast future prices. By employing advanced time-series techniques, this study seeks to:

- **Model Development**: Identify the most suitable time-series models for analysing the stock prices of INFOSYS and TCS and their relationships with the NIFTY IT Index.

- **Forecasting**: Generate accurate short-term forecasts for INFOSYS and TCS stock prices, which can guide investors in making informed financial decisions.

- **Market Insights**: Examine the influence of sectoral trends (as represented by the NIFTY IT Index) on individual IT stocks to uncover patterns and dependencies that reflect broader market dynamics.

- **Decision Support**: Provide actionable insights to investors, portfolio managers, and policymakers by evaluating market trends and stock performance.

Data Description

The dataset used in this study was sourced from Kaggle, specifically from the dataset titled "National Stock Exchange Time Series" (https://www.kaggle.com/datasets/atulanandjha/national-stock-exchange-time-series). The data originates from the official National Stock Exchange (NSE) website and provides comprehensive stock market time-series data.

This project focuses on the daily stock price data for INFOSYS, TCS, and the NIFTY IT Index, covering the period from **January 1, 2015, to December 31, 2015**. The dataset contains the following key variables for each stock/index:

- **Open**: Opening price for the day.
- **High**: Highest price during the day.
- **Low**: Lowest price during the day.
- **Close**: Closing price for the day.
- **Volume**: Number of shares traded during the day.

For this analysis, the **closing prices** of INFOSYS, TCS, and the NIFTY IT Index were extracted and used as the primary variables of interest. These closing prices are analysed to study the relationships among the stocks and the index and to develop time-series forecasting models.

Feature Selection

A correlation matrix visually represents the pairwise correlations between variables, providing insights into their linear relationships. In the context of building a time series model, the correlation matrix helps identify the strength of relationships between variables and detect multicollinearity among predictors. For the Infosys, TCS, and Nifty dataset, constructing a correlation matrix can reveal how these variables interact with each other and their potential predictive power for the target variable. This understanding aids in selecting relevant features and improving model performance.

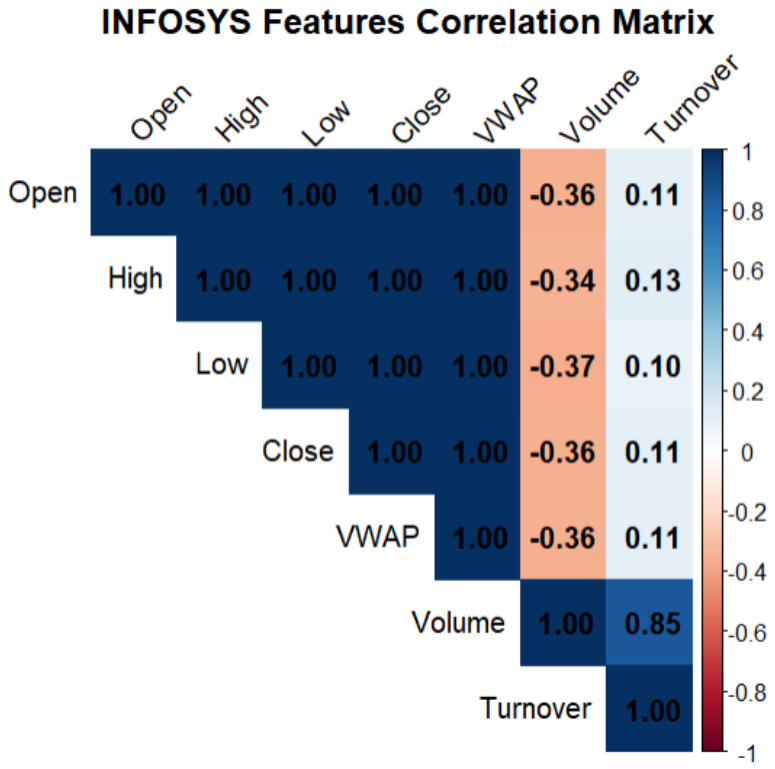

Figure 1Infosys Features Correlation Matrix

Close Price is a common choice as it represents the final price at which a stock is traded on a given day. Volume variable can be used to gauge market sentiment and potential price movements.

Given the high correlation between Open, High, Low, and Close, and considering the importance of the final price at the end of the trading day, choosing the Close price as the primary variable for your time series analysis is a wise decision.

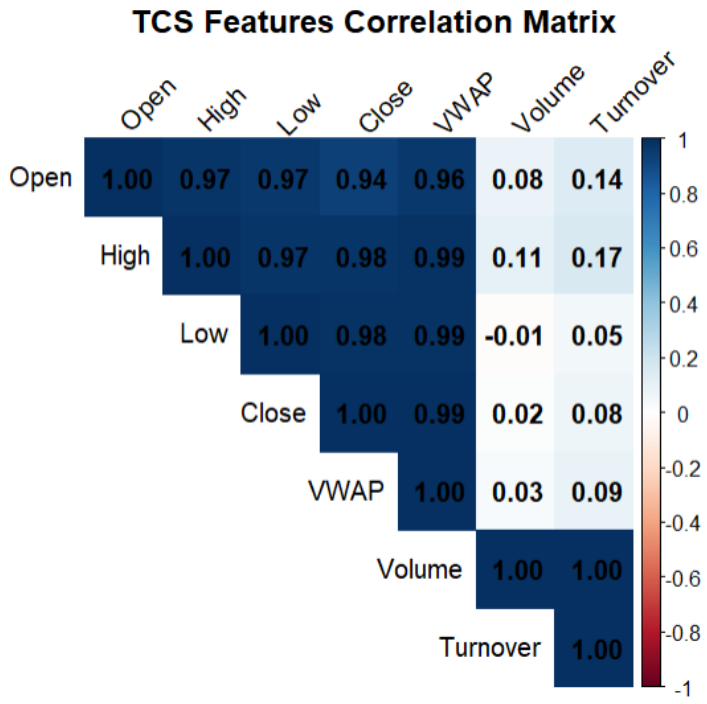

Figure 2 TCS Features Correlation Matrix

The Open, High, and Low prices are highly correlated with the Close price. This indicates that they often move together and might not provide additional significant information. The Close price represents the final price at which the stock was traded on a given day. Therefore, for your time series analysis on TCS, focusing on the Close price as the primary variable is recommended.

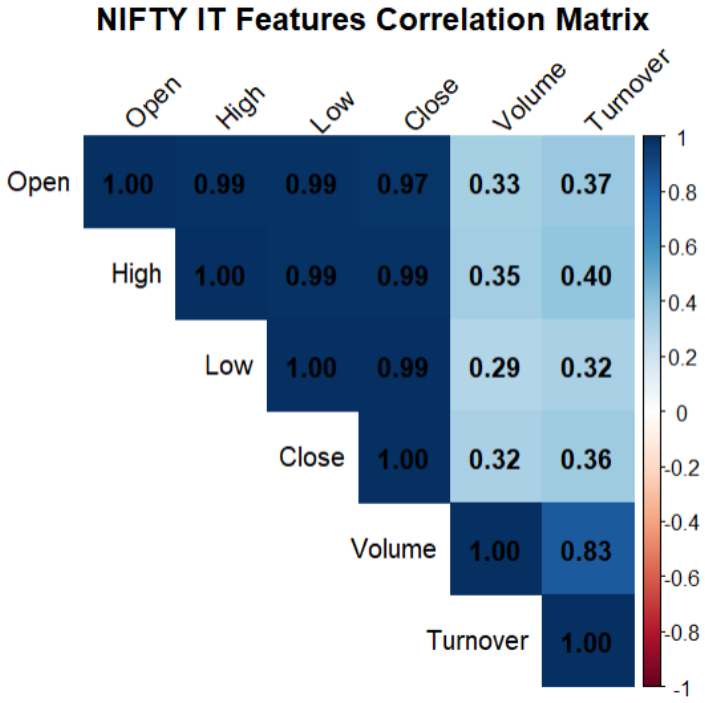

Figure 3 Nifty IT Features Correlation Matrix

Based on the correlation matrix, the Close price is the most suitable feature for time series analysis. By choosing Close, we avoid the high correlation with other price features, reducing the risk of multicollinearity in our model. While Volume can provide insights into market activity, it might not be the most direct predictor of price movements. By focusing on the Close price, you can build a robust time series model for the NIFTY IT index.

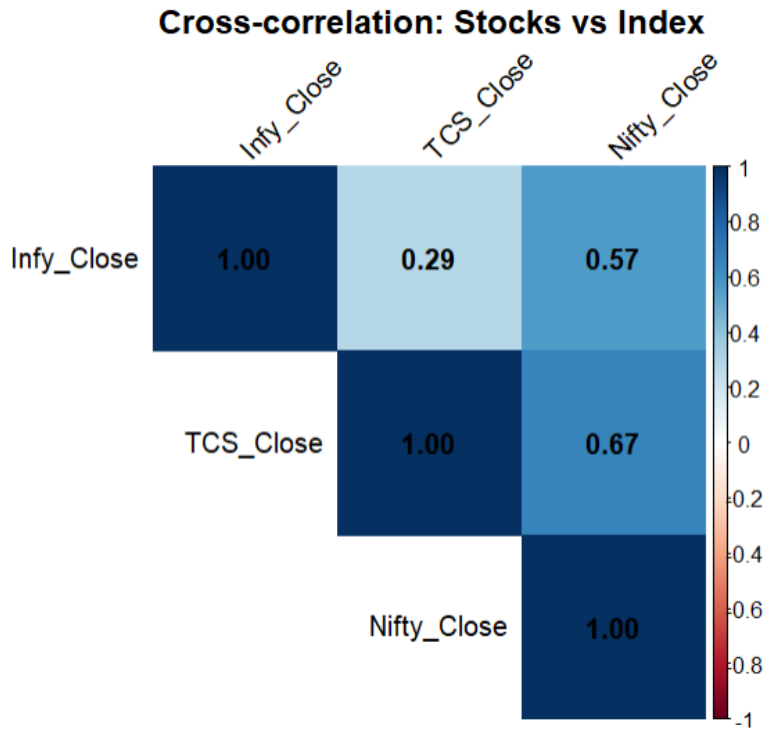

Figure 4 Cross - Correlation Stock vs Index

The correlation matrix you provided shows the pairwise correlations between the closing prices of Infosys, TCS, and the Nifty Index. This correlation matrix suggests that the Nifty Index has a stronger influence on TCS's price movements compared to Infosys. All three pairs of stocks show positive correlations, indicating that they tend to move in the same direction. TCS and the Nifty Index have the strongest correlation (0.67), suggesting that TCS's price movements are closely tied to the overall performance of the Nifty Index. We move forward with closing prices of Infosys, TCS, and the Nifty Index as your primary variables for our time series analysis.

Hypotheses & Research Questions

Stationarity Hypothesis:

- Null Hypothesis: The time series data (Infosys, TCS, Nifty IT) are stationary.
- Alternative Hypothesis: The time series data are non-stationary.

Correlation Hypothesis:

- Null Hypothesis: There is no significant correlation between Infosys, TCS, and Nifty IT.
- Alternative Hypothesis: There is a significant correlation between Infosys, TCS, and Nifty IT.

Research Questions

- Trend Analysis**:** What is the overall trend of each time series?
- Seasonality**:** Is there any seasonal pattern in the data?
- Forecasting**:** What are the predicted values for future time periods?

Plot & Information

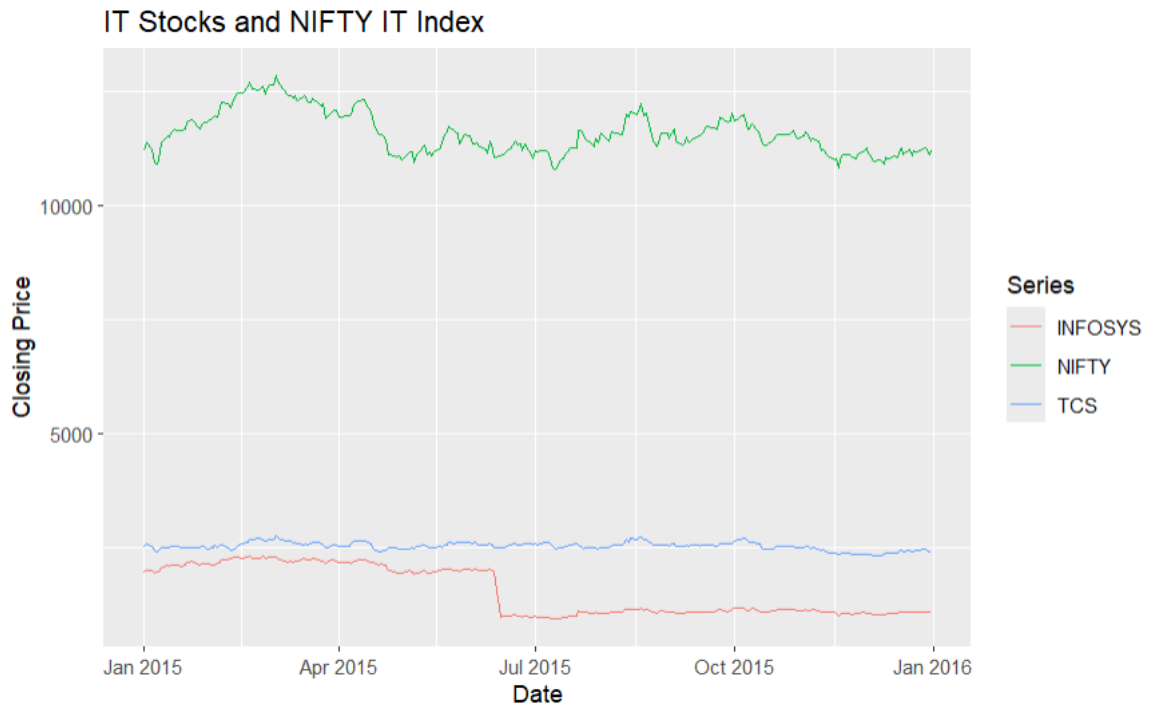

Figure 5 Time series slot – IT Stocks (Infosys & TCS) and Nifty IT Index

All three series (INFOSYS, NIFTY IT Index, and TCS) exhibit an overall upward trend throughout the year 2015. The NIFTY IT Index appears to be the most volatile, with its price fluctuating more significantly than the other two series. There seems to be a positive correlation between the three series, meaning they tend to move in the same direction.

Specific Observations:

NIFTY IT Index: Starts at the highest price among the three. Exhibits the most significant fluctuations, with both sharp rises and drops. Generally, follows the upward trend of the other two series.

INFOSYS: Starts the year at a relatively lower price compared to the other two. Experiences a sharp rise in the middle of the year. Shows some fluctuations but maintains an upward trend overall.

TCS: Starts at a price level like INFOSYS. Shows a steady upward trend with fewer fluctuations compared to the NIFTY IT Index.

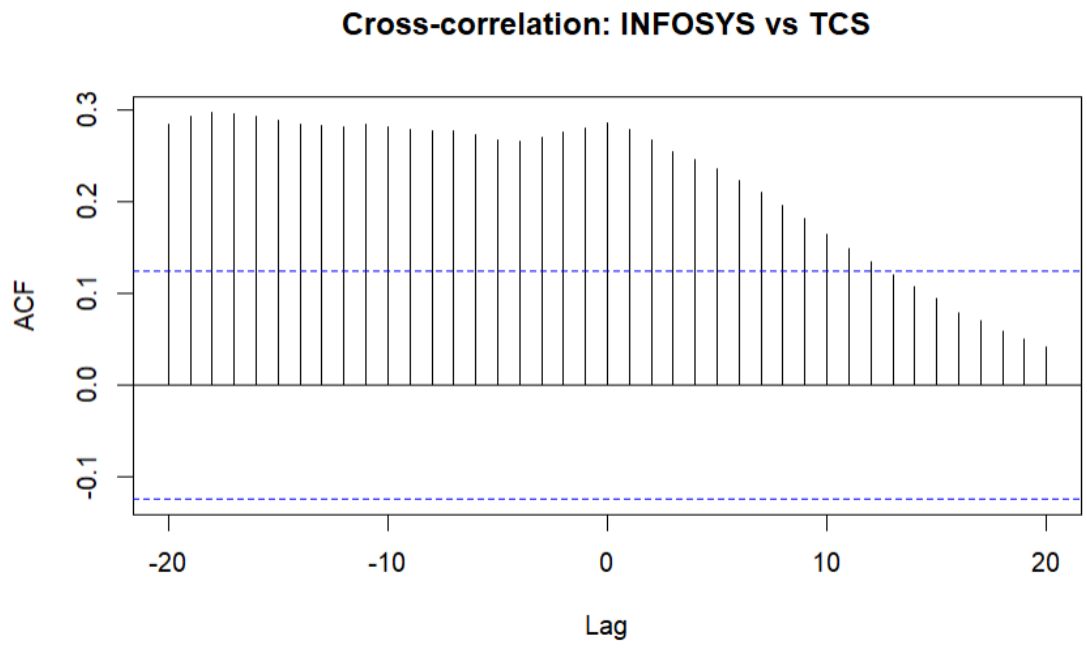

Figure 6 Cross-correlation: INFOSYS vs TCS

INFOSYS vs TCS:

This Figure 6 shows that INFOSYS and TCS stocks have a moderate relationship. When one stock moves, the other tends to move in the same direction, but the connection isn't very strong (around 0.3). They are competitors in same industry.

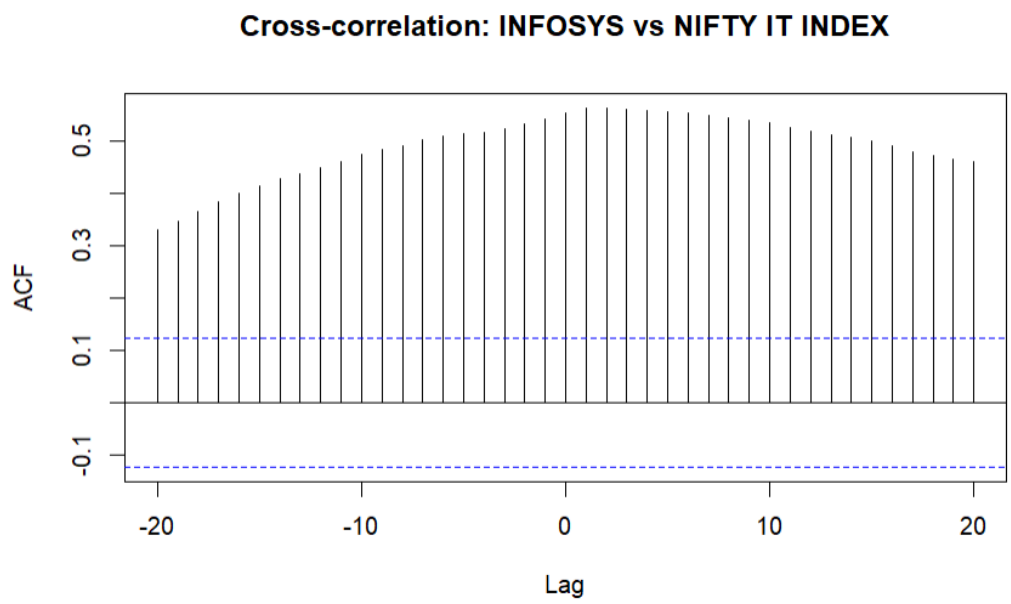

Figure 7 Cross-correlation: INFOSYS vs NIFTY IT Index

INFOSYS vs NIFTY IT INDEX

This Figure 7 reveals a stronger connection between INFOSYS and the NIFTY IT INDEX (around 0.5). This stronger relationship exists because INFOSYS is a major component of the index. The relationship stays consistent over time, showing that INFOSYS significantly influences the index's movement.

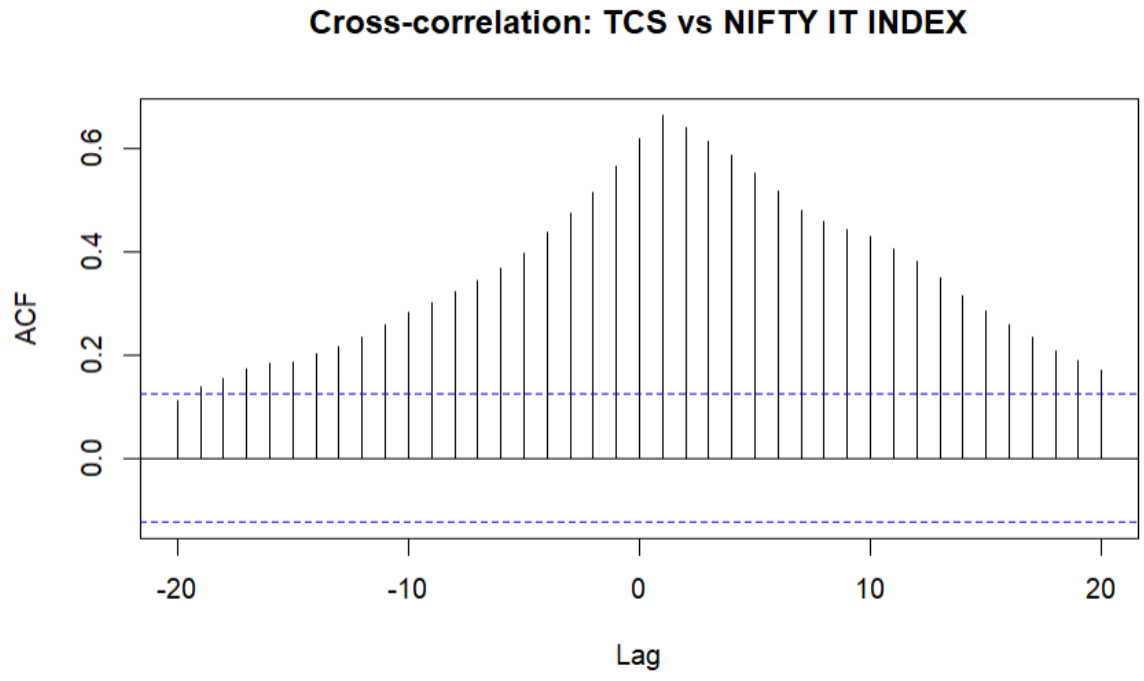

Figure 8 Cross-correlation: TCS vs NIFTY IT Index

TCS vs NIFTY IT INDEX

This Figure 8 shows the strongest relationship of all (around 0.6). TCS has the most influence on the NIFTY IT INDEX, likely because it's the largest IT company by market value. When TCS's stock price changes, it has a bigger impact on the index than INFOSYS does.

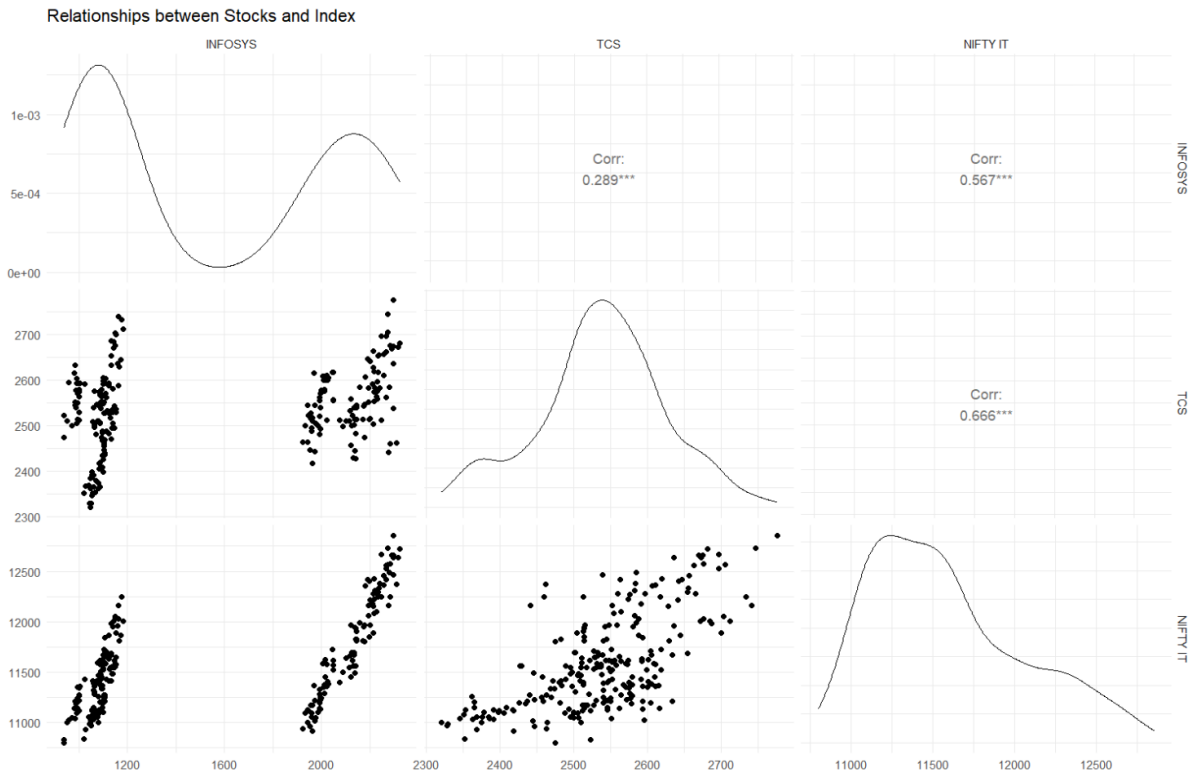

Figure 9 Scatter plot: Relationship between stocks and Index

Same as the cross-correlation TCS has a stronger relationship with the Nifty IT index than Infosys. This could be due to various factors, such as sector-specific trends, market sentiment, and economic indicators. Also, this figure 9 shows a moderate positive relationship, indicating a stronger association between Infosys and the overall IT index.

The *** indicates statistical significance at the $p < 0.001$ level. All correlations are positive and statistically significant, with:

- TCS showing the strongest relationship with NIFTY IT (0.666)
- INFOSYS showing moderate relationship with NIFTY IT (0.567)
- A weaker but still significant correlation between INFOSYS and TCS (0.289)

Figure 9 is clear evidence to reject the null correlation hypothesis and accept the alternative hypothesis.

Stationarity Check

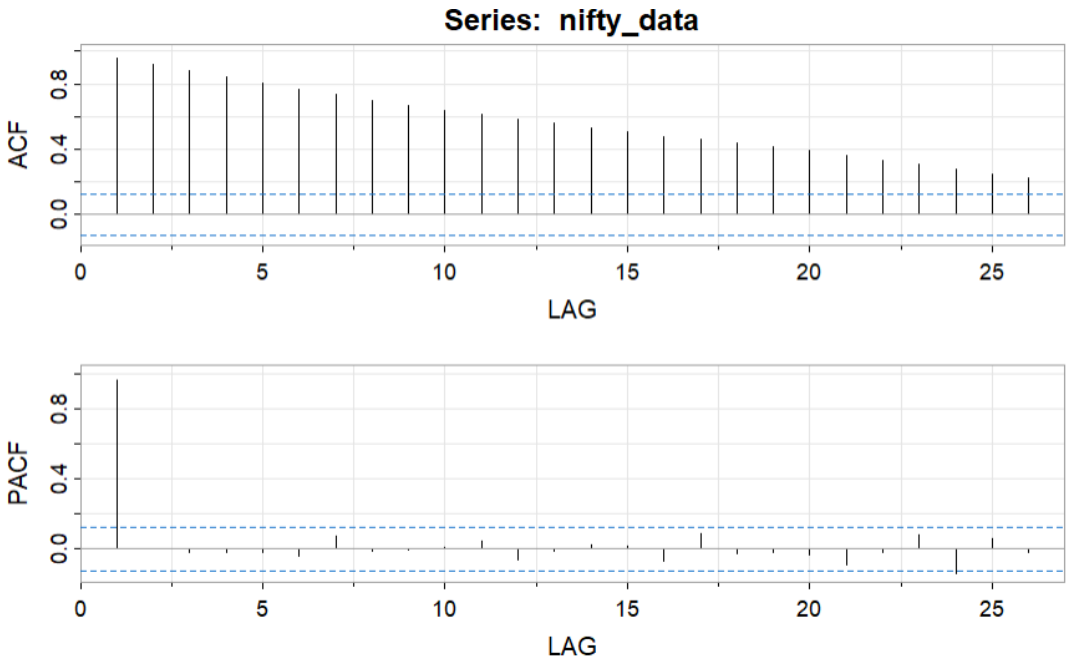

Figure 10 Nifty ACF & PACF Plot

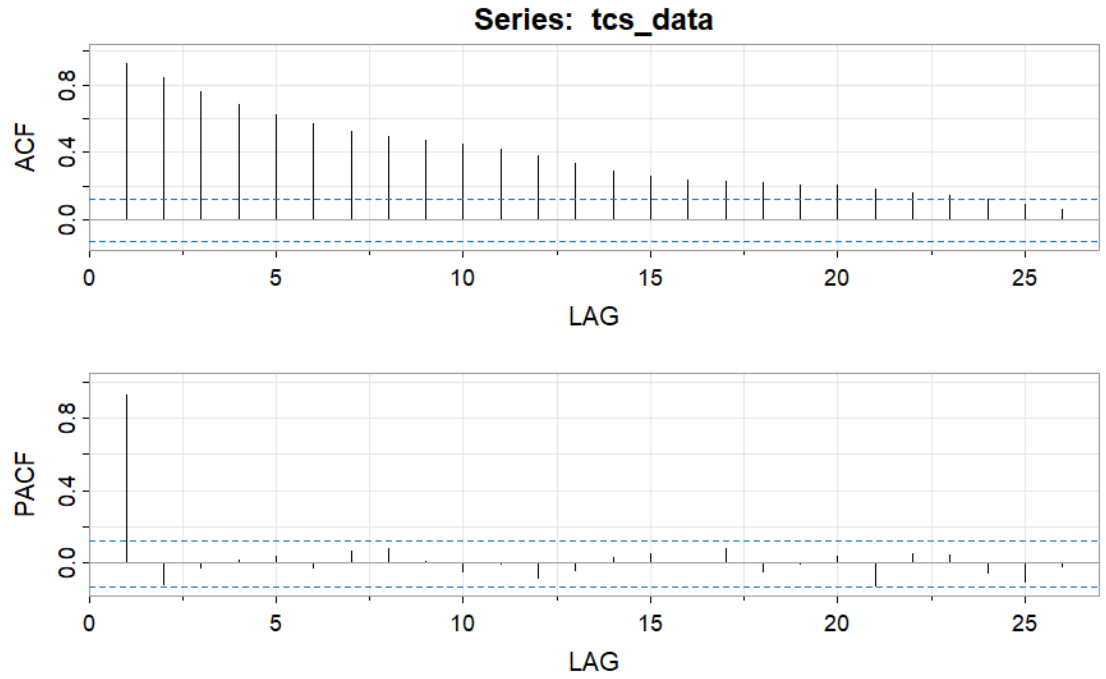

Figure 11 TCS ACF & PACF Plot

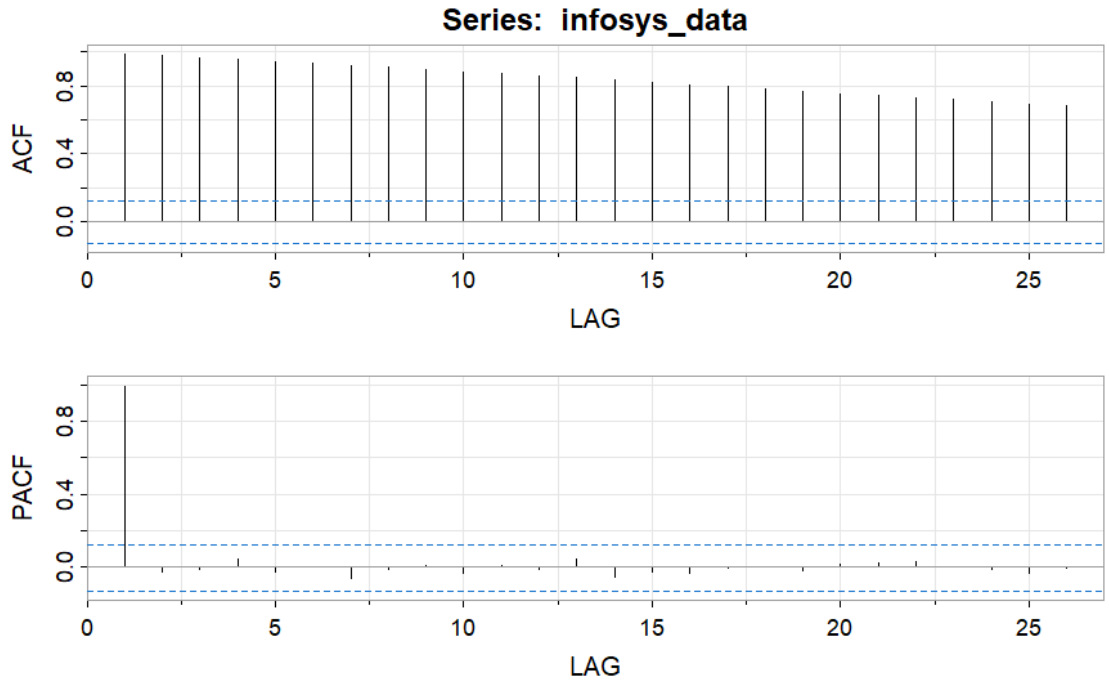

Figure 12 Infosys ACF & PACF Plot

NIFTY IT Index, TCS and INFOSYS all three Time series have following pattern:

- ACF plot shows slow decay pattern/ persistent high values
- PACF plot shows significant spike at lag 1
- Pattern indicates non-stationarity in the series

All three Time series are non-stationary. we fail to reject the null hypothesis of non-stationarity. Series need differencing to achieve stationarity.

We need to follow the following steps:

1. Apply first-order differencing
2. Recheck stationarity of differenced series
3. Then proceed with time series model

Series Differencing

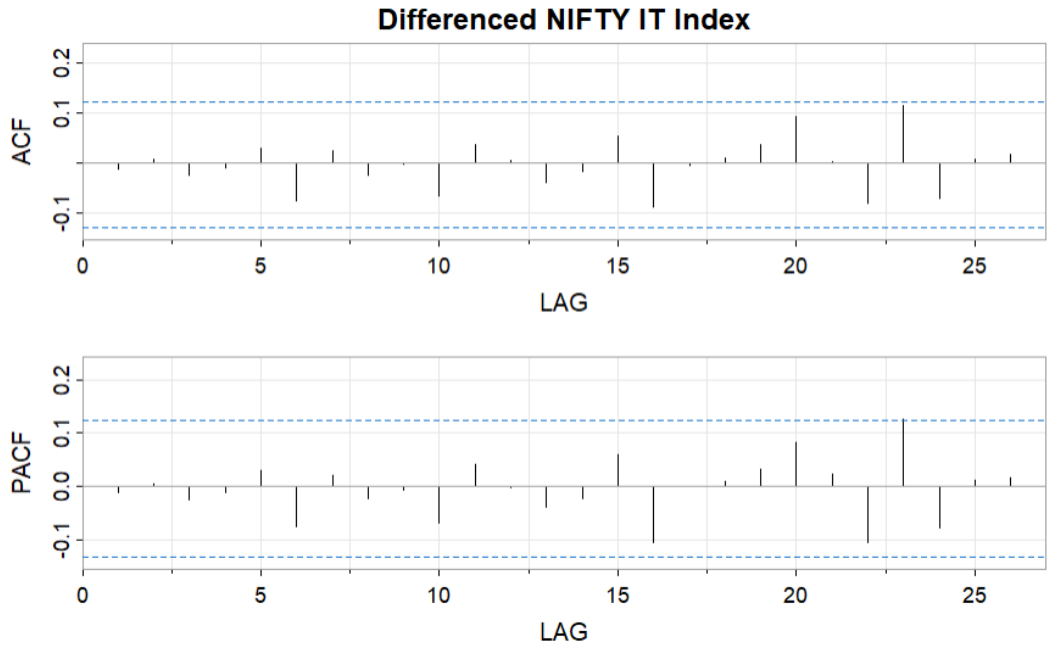

Figure 13 : Differenced NIFTY IT Index

NIFTY IT Index

- After differencing, most spikes fall within significance bounds (blue dashed lines)
- PACF shows similar pattern with no clear seasonal component
- Your suggestion of ARIMA (1,1,0) is reasonable as a starting point

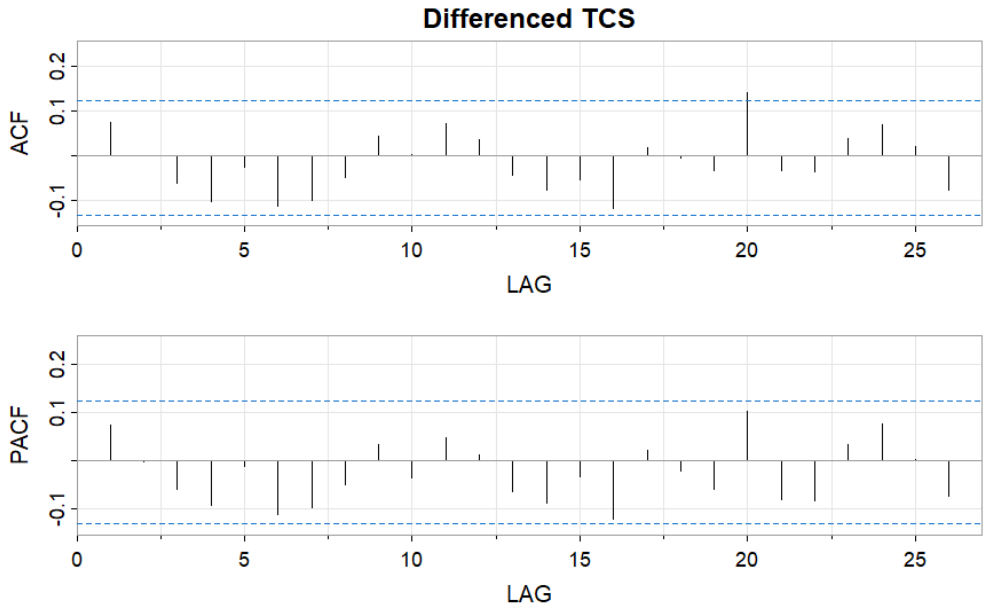

Figure 14 Differenced TCS

TCS

- Differenced series shows more consistent pattern
- ACF shows significant spikes at early lags (1-7)
- PACF has significant spike at lag 1 and lag 20
- Your suggestion of ARIMA (4,1,0) makes sense given the pattern of spikes

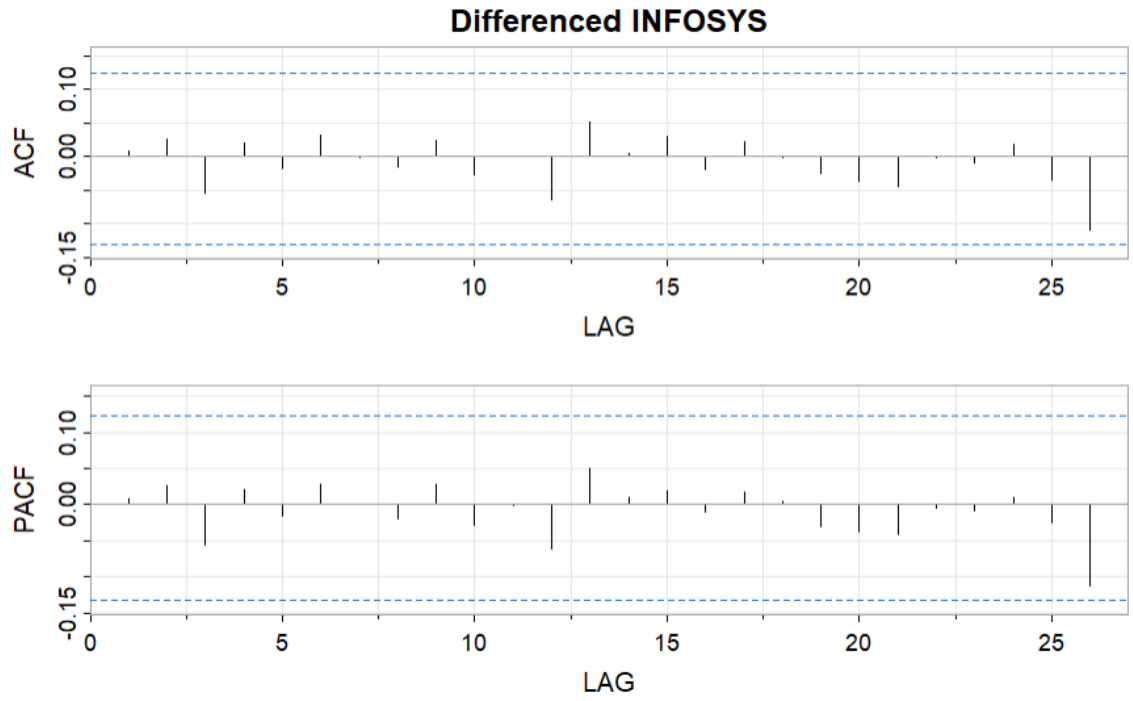

Figure 15 Differenced INFOSYS

INFOSYS

- Differenced series shows good stationarity
- ACF shows fewer significant spikes
- PACF shows significant spike at lag 1
- ARIMA (1,1,0) is a good starting point as suggested

The differencing has indeed successfully removed trends and achieved stationarity.

Selecting Model

Selecting Model for Nifty

We started with our choosing model which is ARIMA (1,1,0).

```
Coefficients:
         Estimate     SE t.value p.value
ar1       -0.0119 0.0638 -0.1865  0.8522
constant  -0.0247 7.9876 -0.0031  0.9975

sigma^2 estimated as 16133.52 on 245 degrees of freedom

AIC = 12.55082  AICc = 12.55102  BIC = 12.59345
```

Figure 16 Model 1 Nifty – ARIMA (1,1,0)

Constant term was not significant (p-value = 0.9975), we need to try some simple model. Move forward with the ARIMA (1,0,0) Model.

```
Coefficients:
        Estimate       SE t.value p.value
ar1       0.9615   0.0163 58.8737       0
xmean 11528.1995 189.9858 60.6793       0

sigma^2 estimated as 15807.93 on 246 degrees of freedom

AIC = 12.54075  AICc = 12.54095  BIC = 12.58325
```

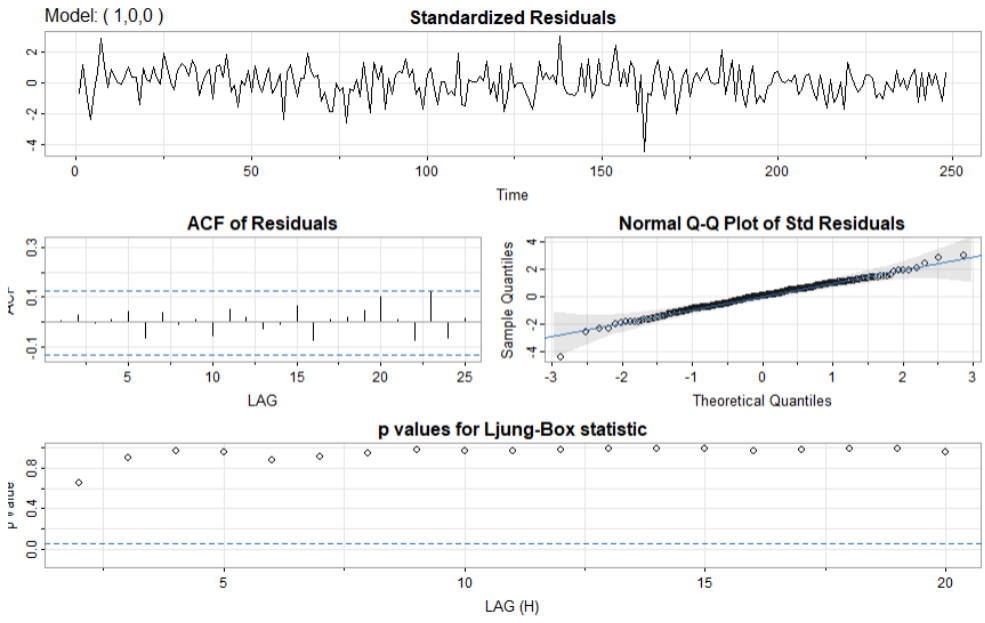

Figure 17 : Model 2 Nifty – ARIMA (1,0,0)

The standardized residuals plot shows relatively constant variance and no obvious patterns. The Ljung-Box test p-values are well above 0.05, indicating no significant residual autocorrelation.

AR (1) coefficient = 0.9615 is highly significant (p-value ≈ 0). The ARIMA (1,0,0) model is appropriate for the NIFTY IT Index.

Selecting Model for TCS

We started with our choosing model which is ARIMA (4,1,0).

```
Coefficients:
         Estimate     SE t.value p.value
ar1        0.0696 0.0634  1.0969  0.2738
ar2        0.0012 0.0637  0.0191  0.9847
ar3       -0.0578 0.0645 -0.8960  0.3711
ar4       -0.0980 0.0646 -1.5180  0.1303
constant  -0.3553 1.9002 -0.1870  0.8518

sigma^2 estimated as 1045.804 on 242 degrees of freedom

AIC = 9.839233  AICc = 9.840241  BIC = 9.924482
```

Figure 18 Model 1 TCS – ARIMA (4,1,0)

All AR coefficients are not significant (p-values > 0.05). We need to consider simpler models like ARIMA (1,0,0) or ARIMA (2,0,0) for better results.

```
Coefficients:
       Estimate      SE  t.value p.value
ar1      1.0352  0.0630  16.4365  0.0000
ar2     -0.1149  0.0632  -1.8177  0.0703
xmean 2534.1780 24.3961 103.8762  0.0000

sigma^2 estimated as 1013.507 on 245 degrees of freedom

AIC = 9.799401  AICc = 9.799797  BIC = 9.856069
```

Figure 19 Model 2 TCS – ARIMA (2,0,0)

In Model 2 TCS is AR (1) coefficient is significant (p-value = 0.0000) and AR (2) coefficient is marginally significant (p-value = 0.0703). Move forward with simpler model.

```
Coefficients:
       Estimate      SE t.value p.value
ar1      0.9283  0.0229 40.6176       0
xmean 2532.8363 27.0484 93.6409       0

sigma^2 estimated as 1027.129 on 246 degrees of freedom

AIC = 9.80457  AICc = 9.804768  BIC = 9.847072
```

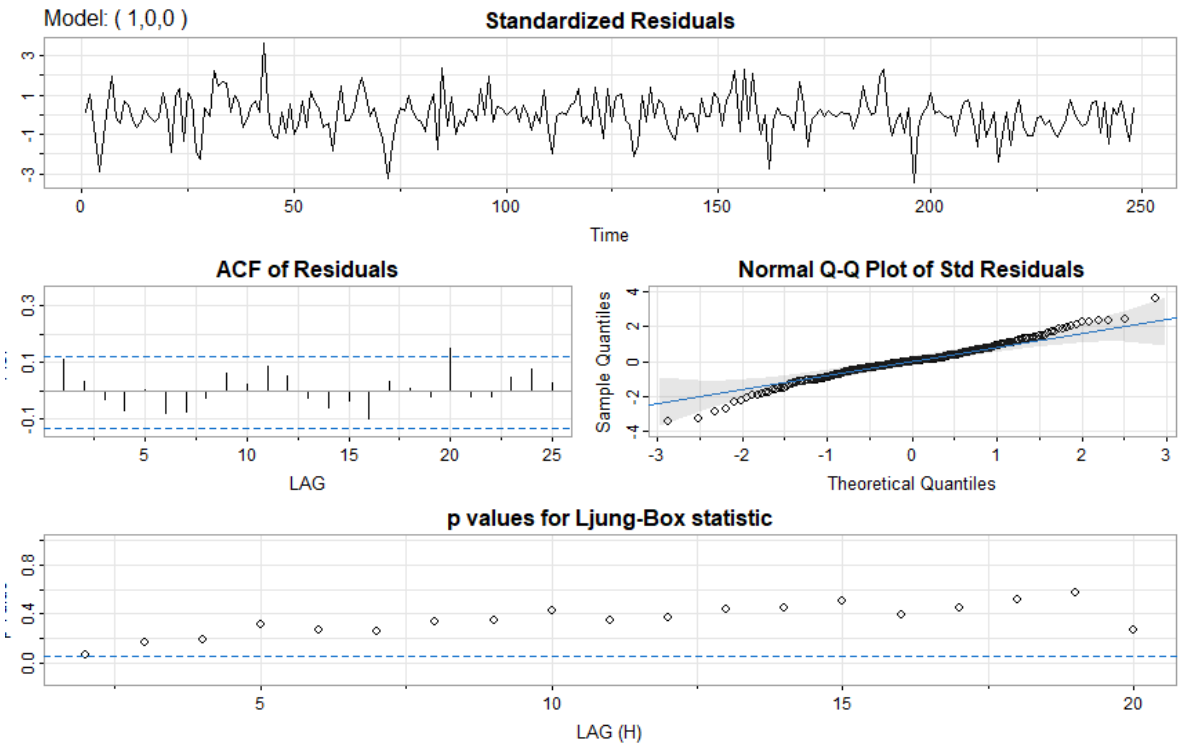

Figure 20 Model 3 TCS – ARIMA (1,0,0)

Model 3 Standardized residuals show no clear patterns or trends. Q-Q plots show residuals following the normal distribution line closely. Ljung-Box test p-values are consistently above 0.05, suggesting no remaining autocorrelation.

The ARIMA (1,0,0) model provides the best balance between model complexity and forecasting accuracy.

Selecting Model for Infosys

We started with our choosing model which is ARIMA (1,1,0).

```
Coefficients:
          Estimate     SE t.value p.value
ar1         0.0074 0.0636  0.1164  0.9074
constant   -3.5163 4.3407 -0.8101  0.4187

sigma^2 estimated as 4585.565 on 245 degrees of freedom

AIC = 11.29284  AICc = 11.29304  BIC = 11.33546
```

Figure 21 Model 1 INFOSYS – ARIMA (1,1,0)

In model 1 Infosys AR (1) coefficient = 0.0074 is not significant (p-value = 0.9074) and Constant term = -3.5163 is not significant (p-value = 0.4187). Move forward with simper model.

```
Coefficients:
       Estimate       SE  t.value p.value
ar1      0.9909   0.0069 143.8366       0
xmean 1546.9765 343.6702   4.5013       0

sigma^2 estimated as 4574.884 on 246 degrees of freedom

AIC = 11.30657  AICc = 11.30677  BIC = 11.34907
```

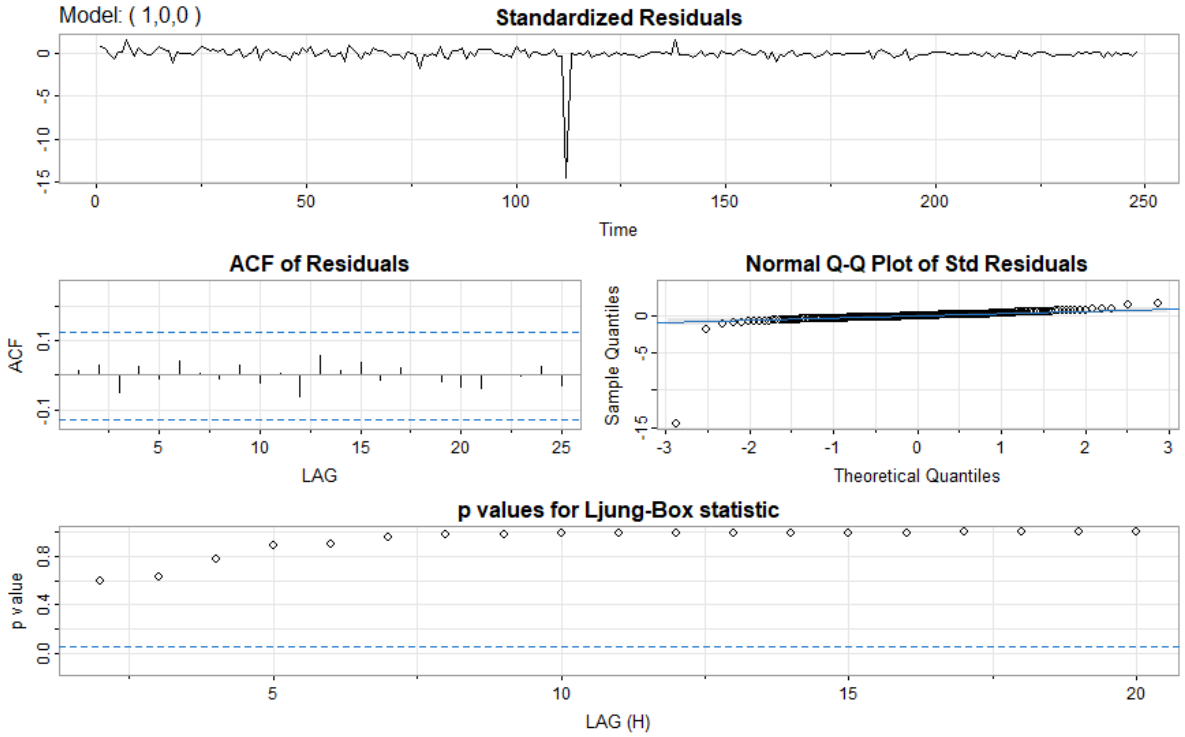

Figure 22 Model 2 INFOSYS – ARIMA (1,0,0)

The standardized residuals plot shows relatively stable variance over time, with one notable outlier around time point 100. Q-Q plot shows good alignment with the theoretical normal distribution line. Ljung-Box test p-values are consistently above 0.8, indicating no significant residual autocorrelation

In this model ARIMA (1,0,0) AR (1) coefficient = 0.9909 is highly significant (p-value ≈ 0) and Mean term = 1546.97 is significant (p-value ≈ 0) so, ARIMA(1,0,0) is the better choice for Infosys time series.

Manual Model selected for the time-series is

Nifty IT Index: ARIMA (1,0,0)

TCS: ARIMA (1,0,0)

Infosys: ARIMA (1,0,0)

Model Comparison with auto. Arima ()

All three series were fitted with ARIMA (1,0,0) models, suggesting a simple autoregressive structure. This selection was based on the ACF and PACF plots, which showed significant spikes at lag 1 and gradual decay patterns. The manual selection prioritized model simplicity and parsimony.

```
Series: nifty_data
ARIMA(0,1,0)

sigma^2 = 16136:  log likelihood = -1547.04
AIC=3096.09   AICc=3096.1   BIC=3099.6
Series: tcs_data
ARIMA(2,1,2)

Coefficients:
         ar1      ar2      ma1     ma2
      1.3138  -0.3998  -1.2709  0.2964
s.e.  0.3375   0.3182   0.3502  0.3497

sigma^2 = 1038:  log likelihood = -1206.43
AIC=2422.85   AICc=2423.1   BIC=2440.4
Series: infosys_data
ARIMA(0,1,0)

sigma^2 = 4598:  log likelihood = -1392.01
AIC=2786.01   AICc=2786.03   BIC=2789.52
```

Figure 23 Auto. Arima Model Produce

The automatic selection produced different results:

- For NIFTY IT Index: ARIMA (0,1,0) was selected.
- For TCS: A more complex ARIMA (2,1,2) model was chosen.
- For INFOSYS: ARIMA (0,1,0) was selected.

Run Auto. Arima Model Selection for Nifty, TCS and Infosys.

Nifty Model

ARIMA (0,1,0)

```
Coefficients:
          Estimate     SE t.value p.value
constant   -0.0128 8.0825 -0.0016  0.9987

sigma^2 estimated as 16135.8 on 246 degrees of freedom

AIC = 12.54287  AICc = 12.54293  BIC = 12.57128
```

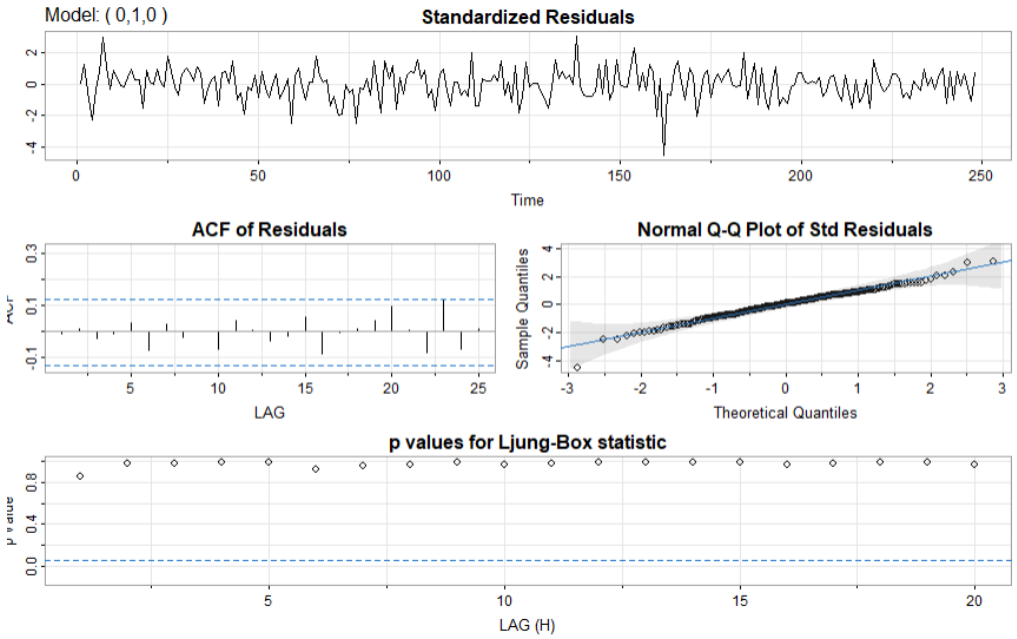

Figure 24 Model 3 Nifty – ARIMA (0,1,0)

Compare with the manual selection and auto. Arima model, while both models have similar AIC values, the ARIMA (1,0,0) model's significant coefficients and lower variance make it more reliable for forecasting NIFTY IT Index values.

For Nifty Series: Choose Manual Model ARIMA (1,0,0).

TCS Model

ARIMA (2,1,2)

```
Coefficients:
          Estimate     SE t.value p.value
ar1         1.2601 0.3602  3.4982  0.0006
ar2        -0.3307 0.3315 -0.9977  0.3194
ma1        -1.2334 0.3720 -3.3153  0.0011
ma2         0.2334 0.3717  0.6281  0.5305
constant   -0.4646 0.2778 -1.6720  0.0958

sigma^2 estimated as 1006.377 on 242 degrees of freedom

AIC = 9.811515  AICc = 9.812523  BIC = 9.896763
```

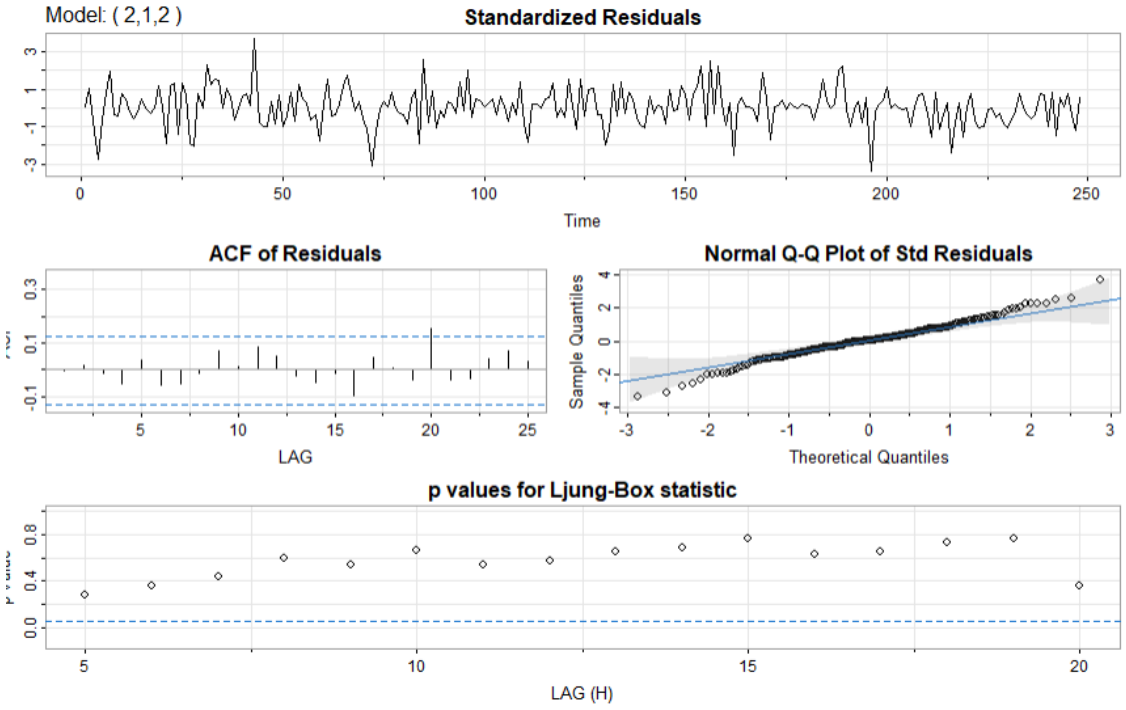

Figure 25 Model 4 Nifty – ARIMA (2,1,2)

The ARIMA (1,0,0) model shows highly significant AR (1) coefficient (0.9283) with p-value ≈ 0. While the ARIMA (2,1,2) has slightly lower sigma^2, its additional complexity and non-significant parameters make it less desirable for forecasting TCS stock prices.

For TCS Series: Choose Manual Model ARIMA (1,0,0).

INFOSYS Model

ARIMA (0,1,0)

```
Coefficients:
         Estimate     SE t.value p.value
constant  -3.5182 4.3088 -0.8165   0.415

sigma^2 estimated as 4585.817 on 246 degrees of freedom

AIC = 11.2848  AICc = 11.28486  BIC = 11.31321
```

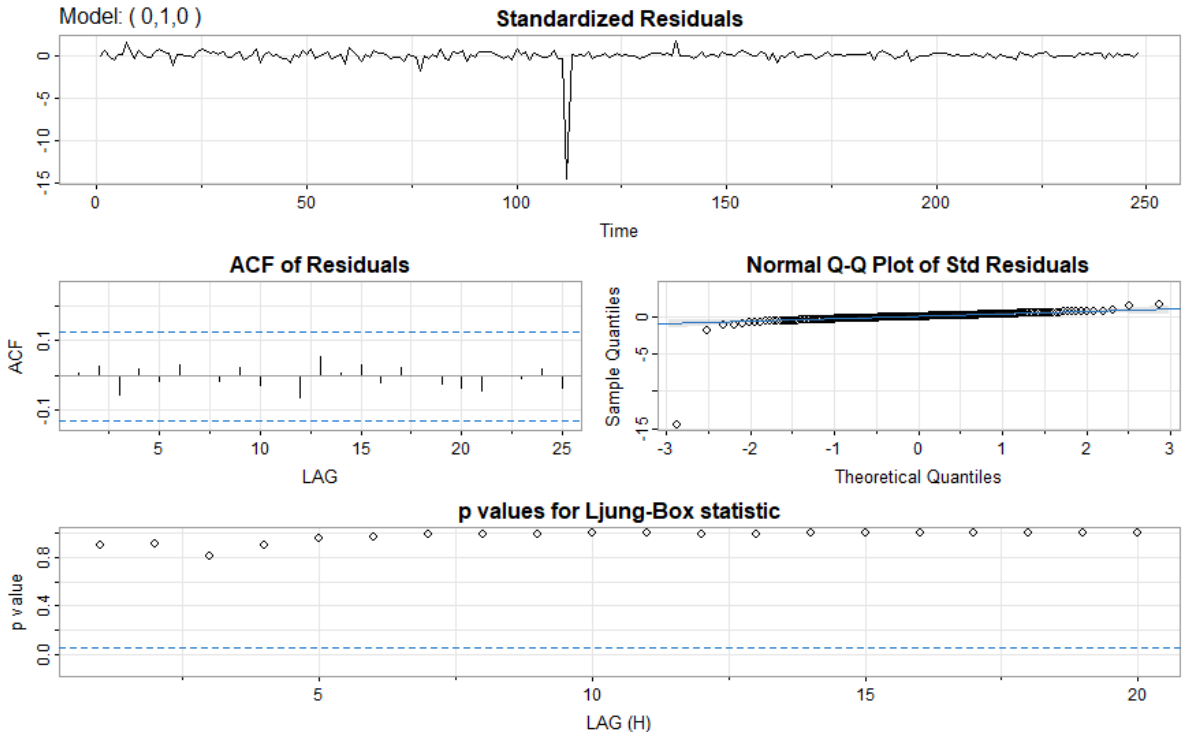

Figure 26 Model 3 Infosys – ARIMA (0,1,0)

The ARIMA (1,0,0) model's significant coefficients and lower variance make it more reliable for forecasting INFOSYS stock prices, despite having a marginally higher AIC.

For TCS Series: Choose Manual Model ARIMA (1,0,0).

These are the Final Model is :

Nifty IT Index: Manual ARIMA (1,0,0).

TCS: Manual ARIMA (1,0,0).

Infosys: Manual ARIMA (1,0,0).

Forecasting

A 12-day forecast horizon provides a good balance between forecasting needs and model reliability for stock price prediction. Forecasting all the series using the ARIMA (1,0,0) model.

Nifty Index Forecasting

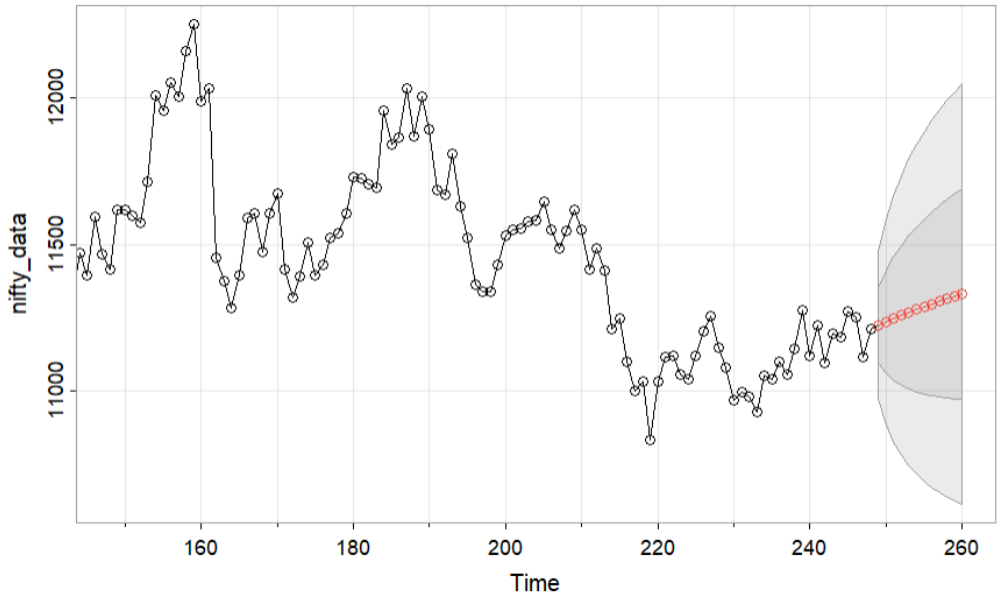

Figure 27 Nifty Index Forecasting for Next 12 days

TCS Series Forecasting

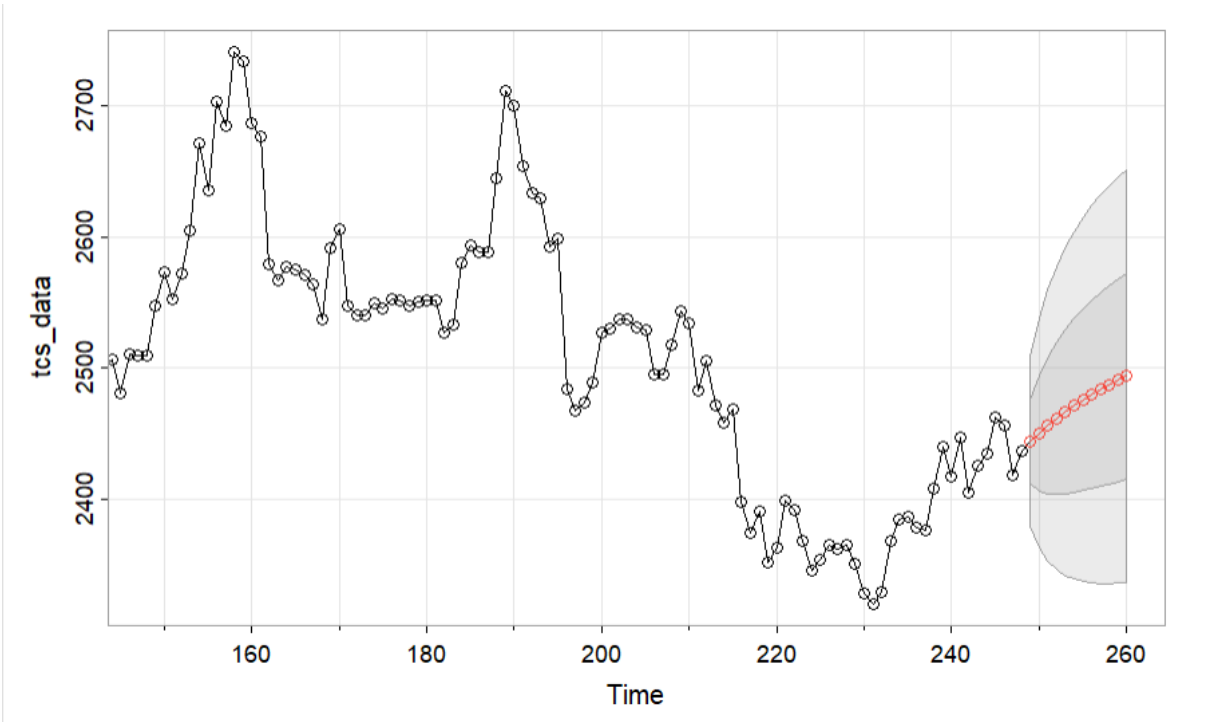

Figure 28 TCS Stock Forecasting for Next 12 days

Infosys Series Forecasting

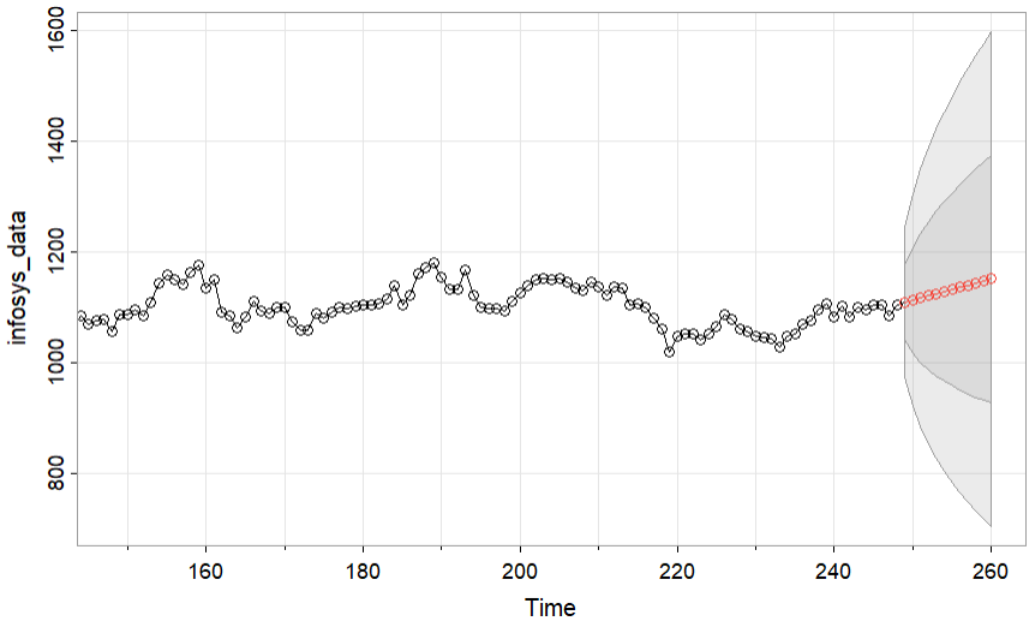

Figure 29 Infosys Stock Forecasting for Next 12 days

Historical accuracy rates for price targets are only around 30 - 40% even for 12–18-days horizons. The widening confidence intervals shown in all three time series plots (NIFTY, TCS, and Infosys) indicate increasing uncertainty over time.

Final Model Equation:

Nifty: $x(t) = 0.9615 * x(t-1) + 443.8357 + w(t)$

TCS: $x(t) = 0.9283 * x(t-1) + 181.6056 + w(t)$

Infosys: $x(t) = 0.9909 * x(t-1) + 14.0804 + w(t)$

Forcast assessment:

The assumption that TCS and Infosys will automatically follow NIFTY IT's movement is oversimplified because:

- Individual stocks can move independently of the index
- Wide confidence intervals suggest high uncertainty in predictions
- External factors can affect individual stocks differently than the index

Forecast Limitations

- Stock prices are influenced by numerous external factors that cannot be captured by time series models alone
- Market conditions can change rapidly, making longer-term predictions less reliable
- The confidence intervals in the forecast plots grow substantially wider beyond the immediate future, suggesting decreased reliability for longer horizons

Analysis of Forecasting

Research Questions

What is the overall trend of each time series?

- NIFTY IT Index displays a downward trend in the original series, with significant volatility and predicted slight upward movement in the forecast period
- TCS exhibits relatively stable behaviour with a declining trend towards the end of original series, followed by a modest upward forecast
- INFOSYS shows more stability compared to both TCS and NIFTY IT, with a relatively flat trend and slight upward movement in the forecast period

Is there any seasonal pattern in the data?

- No significant seasonal patterns are observed in any of the three series
- The differenced NIFTY IT Index shows most spikes within significance bounds
- Minor periodic fluctuations exist but aren't strong enough to indicate true seasonality

What are the predicted values for future time periods?

- NIFTY IT Index: Slight upward trend with widening confidence intervals
- TCS: Moderate upward movement with relatively narrow confidence bands
- INFOSYS: Stable forecast with gradual upward tendency

Conclusion

The analysis of Infosys, TCS, and the NIFTY IT Index revealed important insights into their behaviours and forecasted trends. All three series exhibited non-stationary behaviour, requiring first-order differencing to achieve stationarity. ARIMA (1,0,0) models provided a good fit for all series, effectively capturing short-term dynamics. The absence of significant seasonal patterns in the ACF and PACF plots suggests that the stock market is efficient, with no predictable periodic patterns. Trend analysis showed that the NIFTY IT Index experienced a downward trend in the latter half of 2015 with significant volatility, though forecasts indicate a slight upward movement. TCS exhibited relatively stable behaviour with a declining trend toward the end of 2015, followed by a modest upward movement in the forecast.

Infosys displayed the most stability among the three series, with a flat trend and gradual upward tendency. Short-term forecasts showed moderate reliability, with confidence intervals widening over time for NIFTY IT, while TCS and Infosys had relatively narrower intervals, indicating higher predictability. Statistical testing confirmed the non-stationarity of the series and the need for differencing.

Future research could explore the impact of external economic factors, the integration of trading volume data, and alternative modeling approaches such as machine learning techniques to enhance forecasting accuracy. Overall, the analysis highlights the stability and resilience of Infosys compared to the volatility of TCS and the NIFTY IT Index, providing valuable insights for investors and researchers aiming to understand stock market dynamics.

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