Time Series Analysis of India's Debt-to-GDP Ratio (1951–2024)

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1. Dataset Description

The time series data for this analysis was obtained from the Reserve Bank of India's official database. It contains annual observations on India's long-term external debt as a percentage of GDP, covering the period from 1951 to 2024. The dataset was simplified by removing all other variables, retaining only the year and the corresponding debt-to-GDP ratio.

2. Data Preparation and Cleaning

The Excel file was imported into Stata, and column names were reassigned for readability. Since the original variables were in string format, they were converted into numeric form using the `real()` function. Rows with non-numeric values i.e headers were dropped. The cleaned and converted time variable was retained under the name `year`.

3. Time Series Declaration

The dataset was declared as a time series using the `tsset` command with a yearly frequency.

4. Trend Visualization

To inspect the raw behavior of the series over time, a line plot of the debt-to-GDP ratio was generated. The graph revealed a persistent upward trend with some fluctuations, suggesting some potential structural breaks or policy shifts.

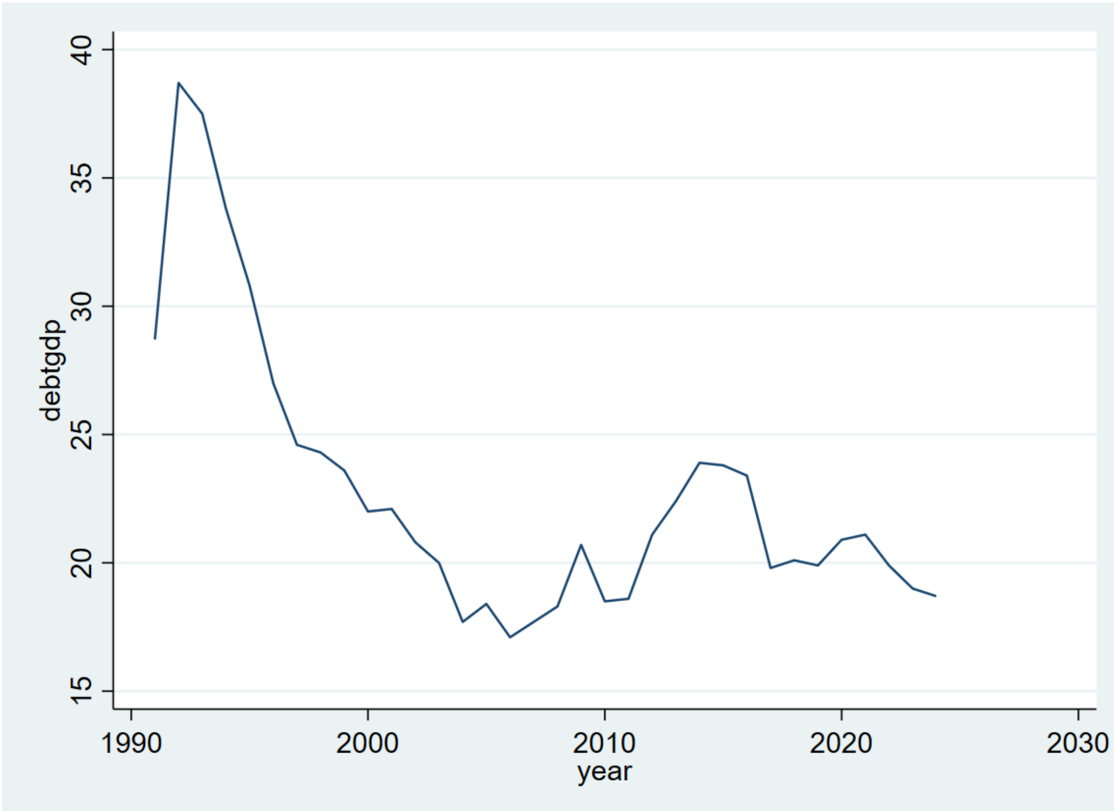

Figure 1: Time Series Plot of Debt-to-GDP Ratio (1951–2024)

5. Testing for Stationarity

To examine the stationarity of the original series, an Augmented Dickey-Fuller (ADF) test was conducted. The test statistic was approximately -1.419, with a p-value of 0.5730. Given the high p-value, the null hypothesis could not be rejected, indicating that the series is non-stationary.

6. Transformation: First Differencing

In order to induce stationarity, the series was first-differenced. A new variable was generated capturing the year-on-year change in the debt-to-GDP ratio. A plot of the differenced series suggested a more stable and mean-reverting behavior. The ADF test on the differenced series yielded a test statistic of -7.490 and a p-value of 0.0000. This indicated that the differenced series was now stationary.

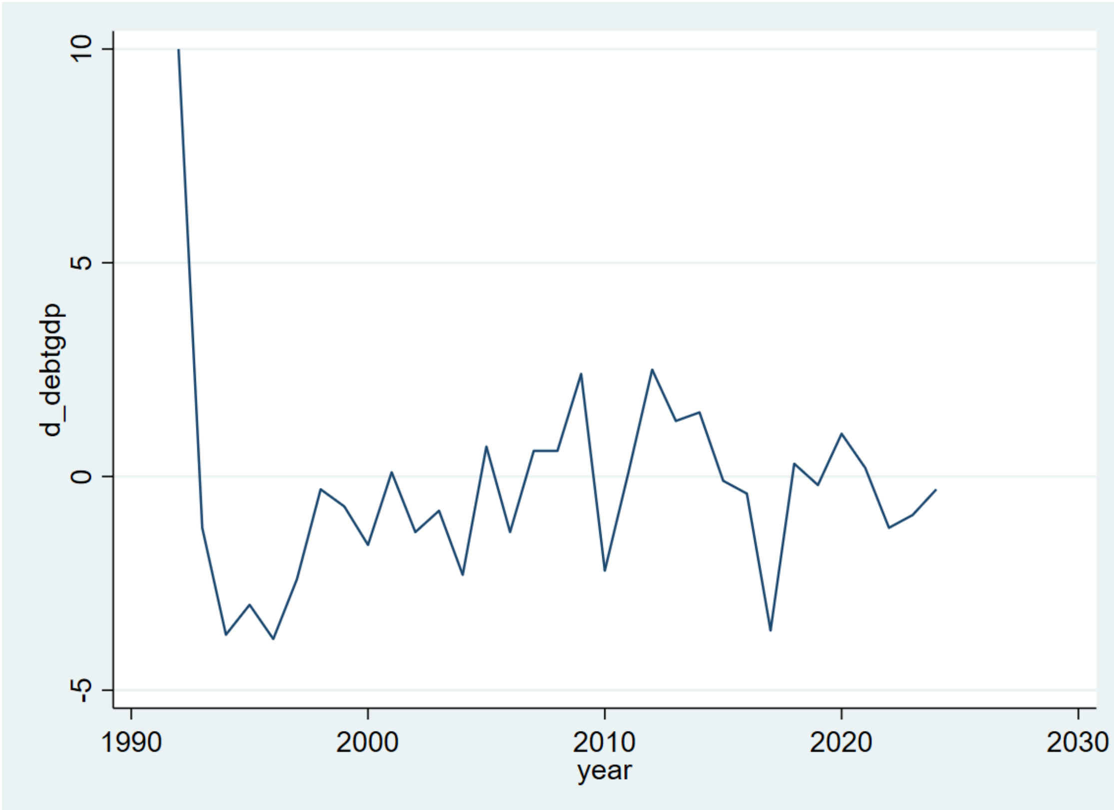

Figure 2: First Difference of Debt-to-GDP Ratio

7. Autocorrelation and Partial Autocorrelation (Correlogram)

The autocorrelation and partial autocorrelation functions of the differenced series decay quickly, with no significant spikes beyond the first lag. This indicates the absence of systematic autocorrelation. To supplement this, a correlogram was generated over 12 lags. The autocorrelation and partial autocorrelation coefficients remain statistically insignificant across all lags. Moreover, the Ljung-Box Q-statistics associated with each lag exhibit high p-values, confirming that there is no significant autocorrelation structure left in the series. The behavior of the series is consistent with white noise. This visual and statistical evidence supports the selection of a random walk model (ARIMA(0,1,0)) for forecasting.

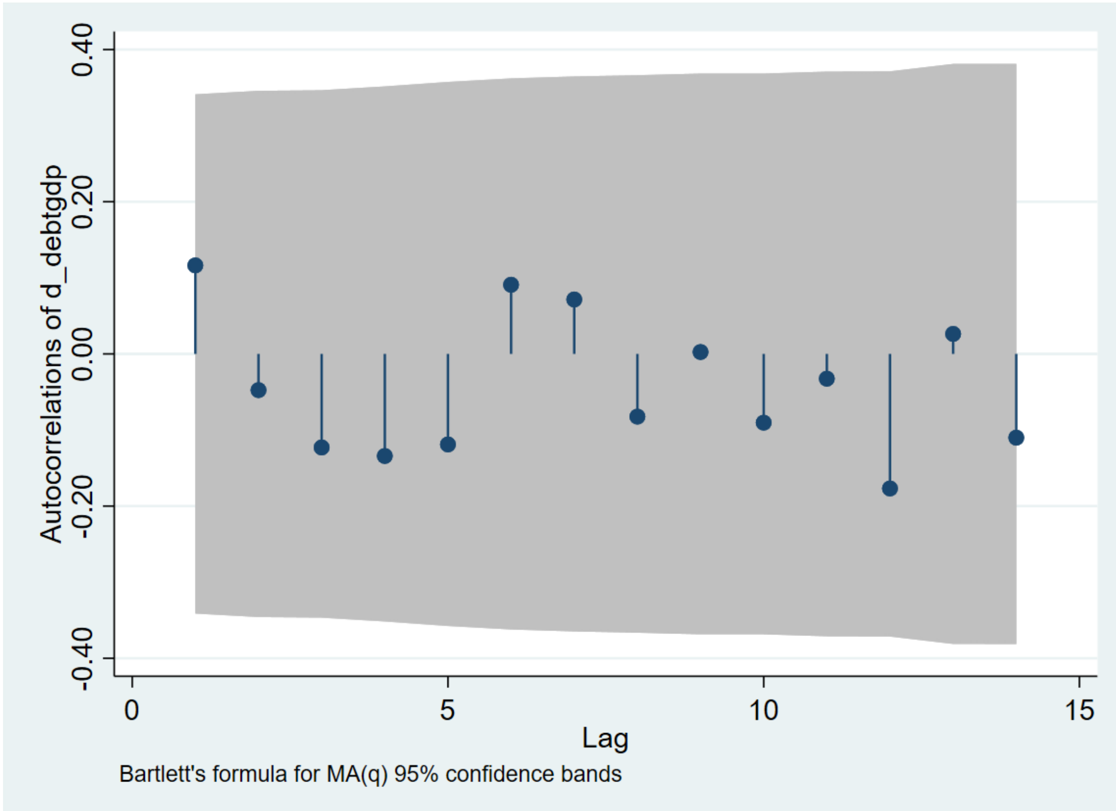

Figure 3: ACF of First Differenced Series

8. Model Identification

Given the lack of significant autocorrelation and the white noise behavior of the first-differenced series, the ARIMA(0,1,0) specification was selected.

9. ARIMA Estimation

The estimation results for the ARIMA(0,1,0) model yielded a log-likelihood of –76.17 and a residual standard deviation of approximately 2.43. As expected, the model includes no autoregressive or moving average terms and assumes that the debt-to-GDP ratio in a given year is best predicted by its value in the previous year, with changes driven entirely by random shocks. This structure is consistent with the random walk hypothesis. Model comparison

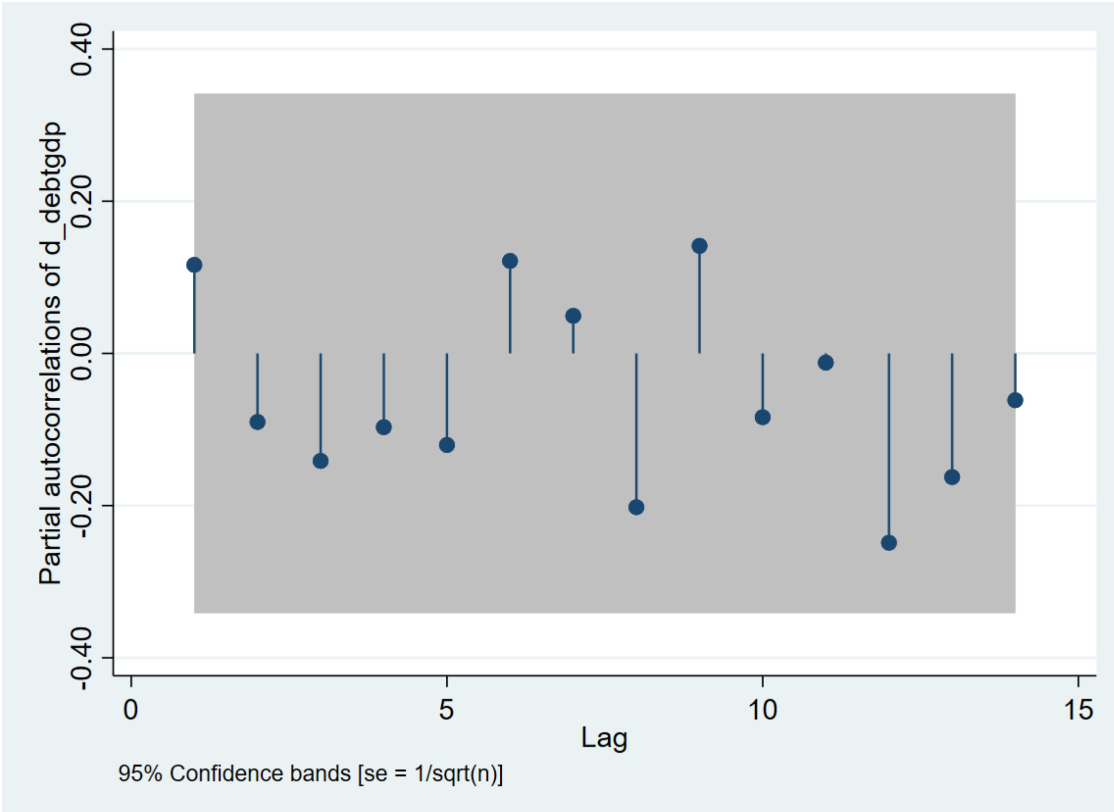

Figure 4: PACF of First Differenced Series

statistics further support this specification. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) for the model were approximately 154.35 and 155.85, respectively. The relatively low values of both AIC and BIC suggest that the ARIMA(0,1,0) model offers a good.

10. Forecasting

Using the estimated ARIMA model, forecasts were generated dynamically from 2024 onward. The forecast plot overlays the actual observed values with the predicted path, which flattens out in line with the model's assumption that future changes are purely stochastic. Given the nature of the ARIMA(0,1,0) model, the forecasts essentially follow a straight line projecting forward the most recent observed value.

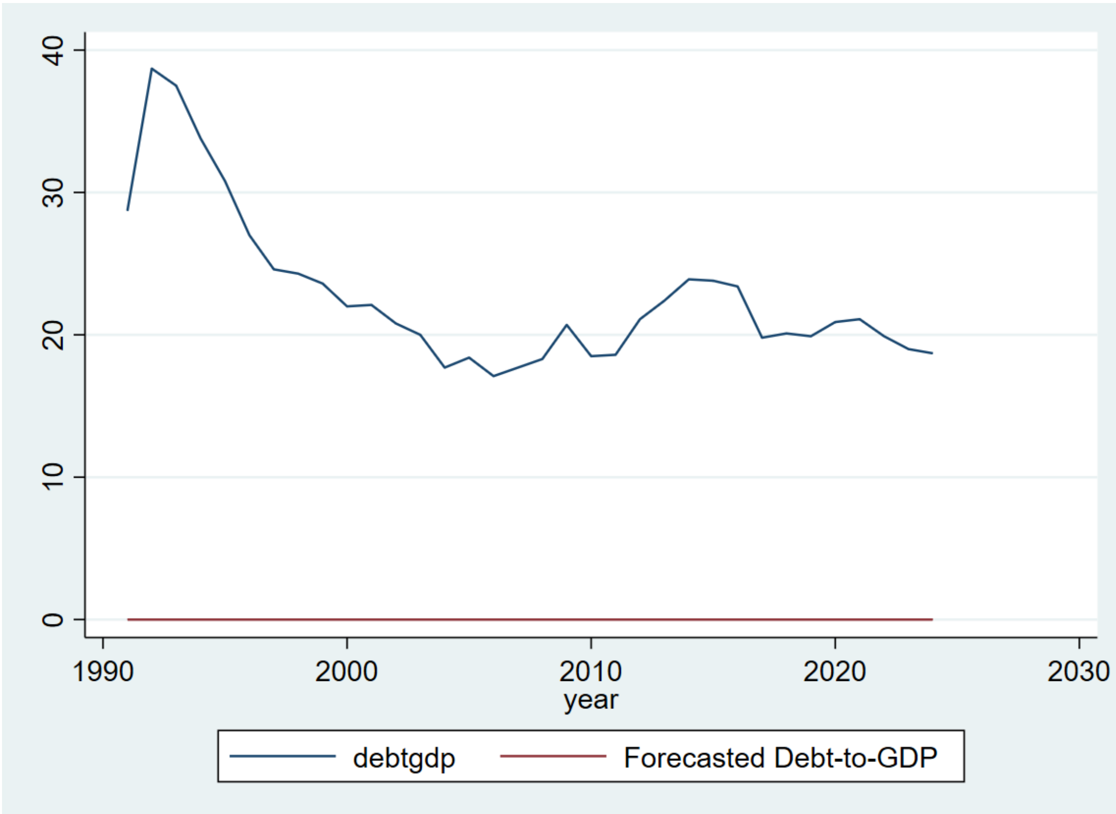

Figure 5: Actual vs Forecasted Debt-to-GDP Ratio

11. Conclusion

This confirms that India's debt-to-GDP ratio is non-stationary in levels but becomes stationary upon first differencing.