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Long-Term FDI Projections for India (2024–2050): Uncovering Trends with ARIMA Modeling

Prof. Dr. Mahendra Kumar[1]
Head Of Department
Business Finance & Economics
Jai Narain Vyas University, Jodhpur (Raj)

Neelam Soni [2]
Business Finance & Economics
Jai Narain Vyas University, Jodhpur (Raj)
Corresponding Author:neelamseni1975@gmail .com

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Abstract
The ARIMA model will be used to forecast trends in Foreign Direct Investment (FDI) in India, utilizing data from 1981 to 2023, sourced from the Reserve Bank of India (RBI). The preprocessing phase will focus on handling missing values, outliers, and anomalies, while stationarity will be assessed using the Augmented Dickey-Fuller (ADF) test, with differencing applied if necessary. Trend and seasonal components will be identified through visual analysis and autocorrelation (ACF) and partial autocorrelation (PACF) plots. The optimal ARIMA (2,1,2) specification will be determined using the Box-Jenkins methodology to capture the dynamic nature of FDI, ensuring stationarity and accounting for short-term fluctuations. Parameter estimation will be conducted using Maximum Likelihood Estimation (MLE) or least squares methods. Residual diagnostics will be performed using the Ljung-Box Q-test to confirm no autocorrelation, while the model's goodness-of-fit will be evaluated with an R-squared value of 90% or higher to ensure robust forecasting performance.

Key Words:- ARIMA Model, Foreign Direct Investment,

I. Introduction

Foreign Direct Investment (FDI) has long been a catalyst for economic growth, providing capital, technology, and management expertise to host countries. In India, FDI has become an essential component of economic policy, contributing to industrial growth, employment, and technology transfer. Tracking and forecasting FDI flows is crucial for policymakers, investors, and economic analysts to make informed decisions and anticipate future economic conditions. Given the complex dynamics of FDI, a reliable model for long-term forecasting is invaluable.

The Box-Jenkins ARIMA model offers a sophisticated approach to time series forecasting, accounting for non-stationarity, trends, and short-term fluctuations in data. This study leverages the ARIMA model to forecast FDI flows in India from 2024 to 2050, based on historical data from 1981 to 2023. Through this model, we aim to provide projections that capture the underlying patterns in FDI, offering insights into India's economic trajectory. By identifying significant autoregressive and moving average components, this analysis highlights both long-term trends and cyclical variations in FDI, with potential implications for macroeconomic planning and policy.

II. Objectives

1. To analyse the historical trends in FDI flows in India from 1981 to 2023.
2. To develop a Box-Jenkins ARIMA model that accurately captures the time-dependent structure of FDI data.
3. To forecast FDI in India from 2024 to 2050 using the ARIMA model and provide a confidence interval for projections.
4. To assess the predictive accuracy and reliability of the ARIMA model in forecasting FDI trends in the long term.
5. To interpret the implications of FDI forecasts for India’s economic growth and policy-making.

III. Review of Literature

Foreign Direct Investment (FDI) has been widely studied for its impact on economic growth and development, particularly in emerging

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economies like India. Prasanna (2010)[1]explored the relationship between FDI and export performance in India, concluding that FDI plays a pivotal role in boosting export activities by improving technological capabilities and fostering global competitiveness. Similarly, Meghani (2014)[2] focused on sector-wise FDI equity inflows in India, analyzing its effects on various sectors and highlighting the significant role of FDI in enhancing industrial development, particularly in sectors like telecommunications, chemicals, and pharmaceuticals. In another study, Jana, Sahu, and Pandey (2019)[3] applied the Johansen cointegration test and Vector Error Correction Model (VECM) to investigate the long-term relationship between FDI and economic growth in India, finding a bidirectional relationship where FDI positively influences growth, and vice versa. Kumar and Siddiqui (2017)[4] conducted an empirical study on the relationship between FDI and macroeconomic variables, focusing on its effects on GDP growth, inflation, and employment, concluding that FDI is crucial for the sustainable economic growth of India. Lastly, Chakraborty and Basu (2002)[5]examined the impact of FDI on the manufacturing sector and economic growth, arguing that FDI not only contributes to capital inflows but also facilitates the transfer of technology, leading to increased productivity and economic dynamism.

IV. Hypotheses

H_{01}: There is no significant increase in Foreign Direct Investment (FDI) in India from 2024 to 2050.
H_{02}: The AR and MA parameters in the ARIMA(2,1,2) model do not significantly improve the accuracy of FDI forecasts.

V. Research Methodology

Forecasting FDI trends in India will be conducted using the ARIMA model, with data spanning from 1981 to 2023, sourced from the Reserve Bank of India (RBI). Data preprocessing will address missing values, outliers, and anomalies, while stationarity will be tested using the Augmented Dickey-Fuller (ADF) test, applying differencing if necessary. Trend and seasonality will be analyzed through visual inspection and ACF/PACF plots. The Box-Jenkins methodology will guide the selection of the optimal ARIMA (2,1,2) model, capturing FDI's past values, ensuring stationarity, and modeling short-term fluctuations. Parameters will be estimated via Maximum Likelihood Estimation (MLE) or least squares methods. Residuals will be tested for autocorrelation using the Ljung-Box Q-test, and the model's goodness-of-fit will be evaluated, aiming for an R-squared value of 90% or higher to ensure high predictive accuracy.

VI. Box-Jenkins ARIMA Model to Forecast FDI Trends in India from 1981 -2050

The Box-Jenkins ARIMA model is a robust statistical methodology widely utilized for forecasting time series data, particularly effective when patterns exhibit seasonality, trends, or cyclic variations. Named after statisticians George Box and Gwilym Jenkins, this model is based on the Autoregressive Integrated Moving Average (ARIMA) approach, which combines aspects of autoregression, differencing, and moving averages to create an adaptable model for non-stationary time series data. The ARIMA model is distinguished by its ability to forecast future values by minimizing the error between observed and predicted values, making it ideal for long-term economic forecasting, such as Foreign Direct Investment (FDI) in India.

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Figure1.1 :- Annual Foreign Direct Investment in India From 1981-2023

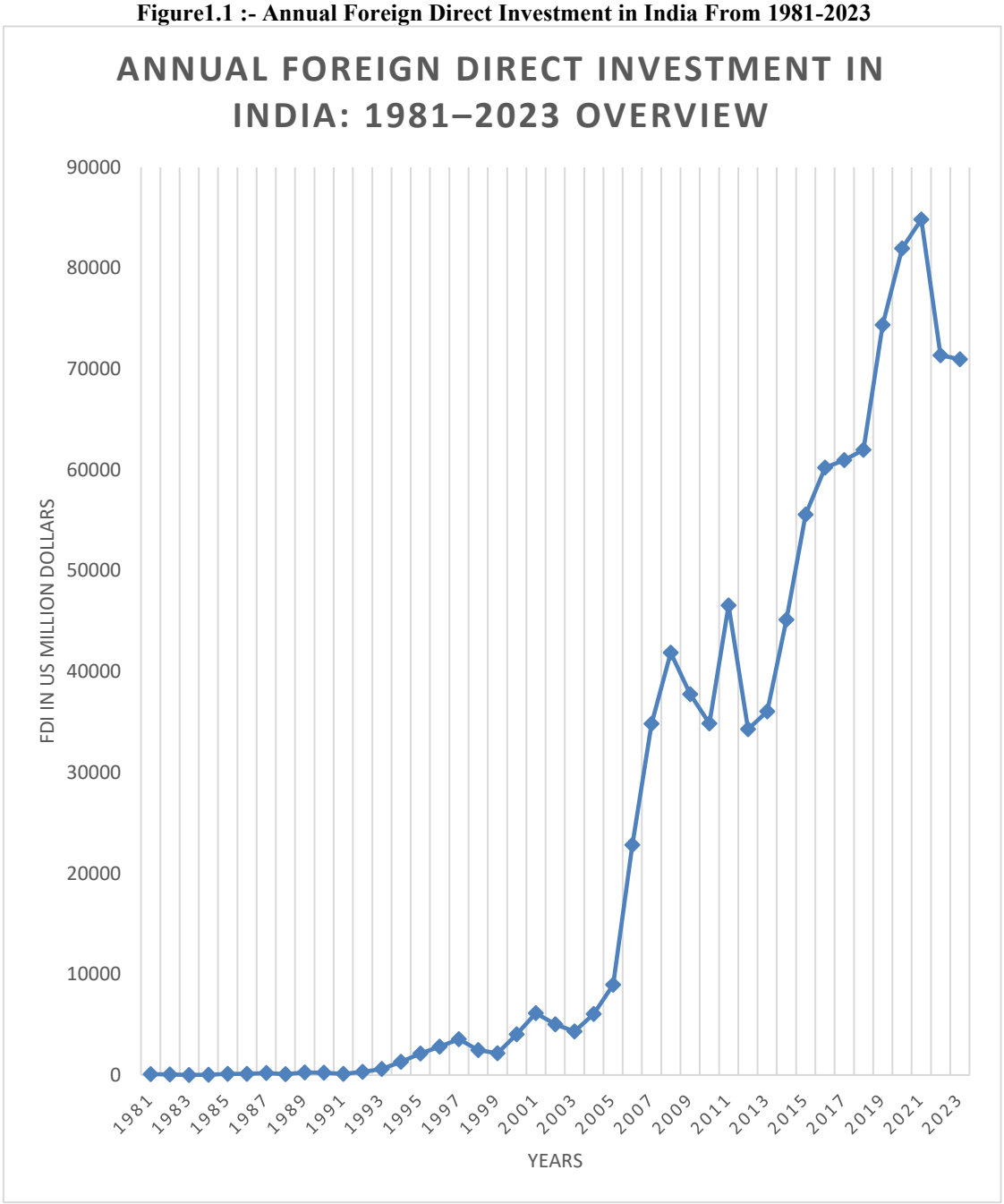

Table 1.1:Projected Foreign Direct Investment (FDI) in India Using the ARIMA Model with Confidence Intervals, 2024–2050 (Amount in US Million dollars)

Years	Projected FDI	Confidence Intervals	
		Lower Confidence Limit	Upper Confidence Limit
2024	77100	66248	87952
2025	81661	65155	98166
2026	80228	60040	100416

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2027	78557	56052	101062
2028	82305	57591	107020
2029	87801	60401	115201
2030	88827	58900	118754
2031	86993	55238	118748
2032	88445	55144	121746
2033	93442	58321	128562
2034	96430	59309	133551
2035	95606	56825	134387
2036	95546	55443	135650
2037	99192	57696	140687
2038	103183	60068	146298
2039	103880	59232	148527
2040	103330	57440	149220
2041	105446	58386	152505
2042	109454	61060	157847
2043	111555	61770	161341
2044	111387	60396	162377
2045	112323	60271	164375
2046	115650	62466	168833
2047	118639	64214	173064
2048	119345	63755	174934
2049	119715	63112	176319
2050	122082	64477	179687

Table 1.2: -Parameter Estimates for ARIMA Model: Analysis of Autoregressive and Moving Average Components

Parameter	Estimate	SE	t-statistics	Sig.
Constant	1780.364	847.742	2.100	0.043
AR Lag 2	-0.916	0.323	-2.834	0.007
MA Lag 2	-0.800	0.386	-2.072	0.045

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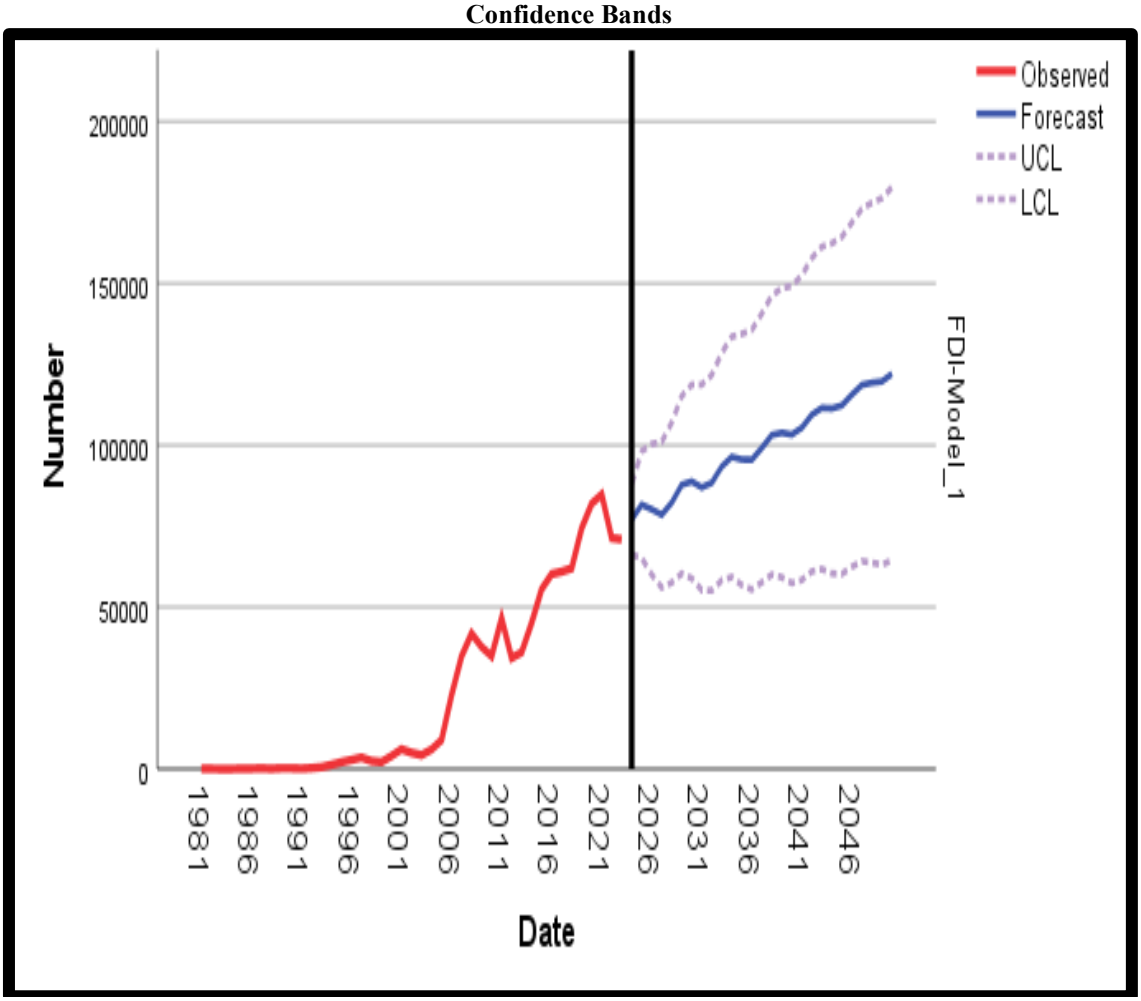
Figure 1.2 :-Projected Foreign Direct Investment (FDI) Growth in India with Confidence Bands



The projected Foreign Direct Investment (FDI) in India shows a steady upward trend from 2024 to 2050, with FDI expected to rise from 77,100 million USD in 2024 to 122,082 million USD by 2050. Confidence intervals indicate variability in projections, with upper and lower limits widening over time, suggesting increased uncertainty in long-term forecasts.

Model Description			
			Model Type
Model ID	FDI	Model_1	ARIMA(2,1,2)

The ARIMA(2,1,2) model, identified as Model_1 in this analysis, is applied to project Foreign Direct Investment (FDI) in India. This model specification includes two autoregressive (AR) terms (p=2), which capture the influence of past FDI values on current values, a first-order difference (d=1) to ensure stationarity by removing any trend, and two moving average (MA) terms (q=2) to account for short-term fluctuations and residual noise in the data. This combination of parameters (p=2, d=1, q=2) makes the model well-suited to address both the trend and randomness within FDI patterns, resulting in a robust forecasting model.

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Figure 1.3: - Autocorrelation Function (At Level)

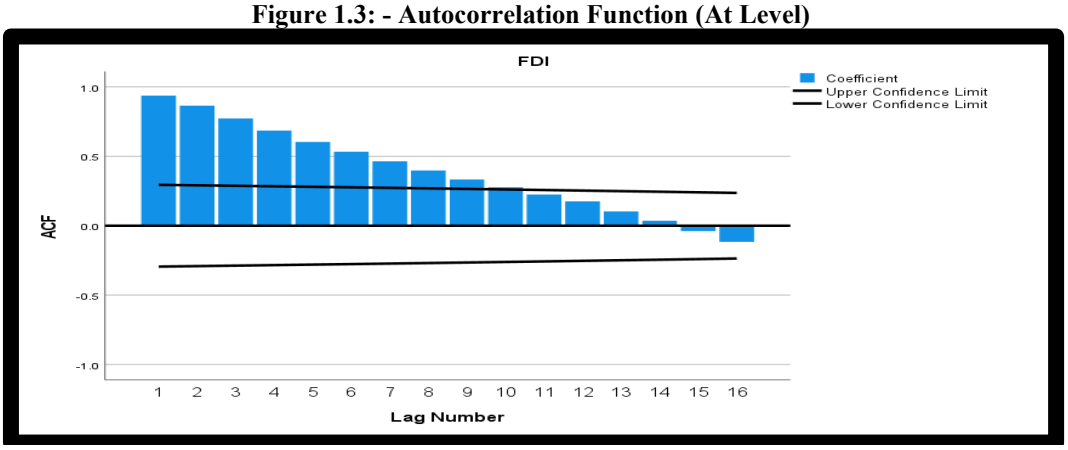
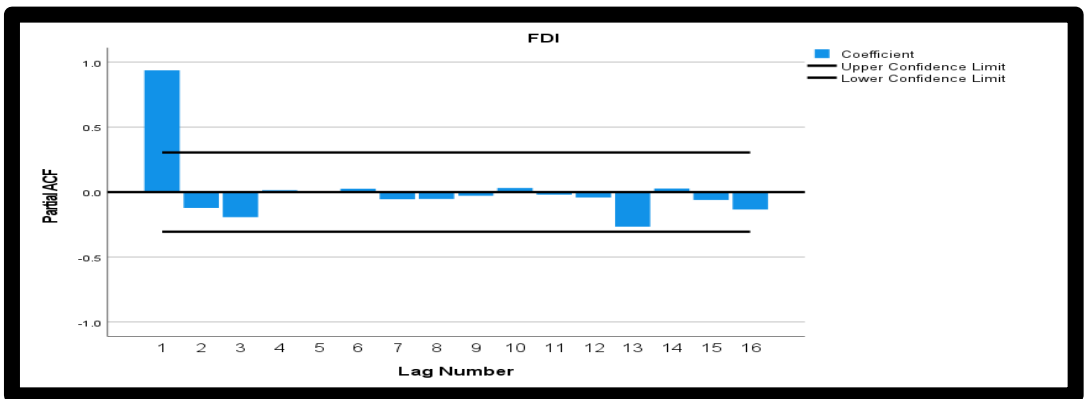


Figure 1.4: - Autocorrelation Function (At Level)



The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots at the level indicate non-stationarity, as they show significant autocorrelations across multiple lags. The ACF specifically exhibits a gradual decline with lags, a pattern often associated with non-stationary data. This gradual decay suggests the presence of a trend or persistent autocorrelation structure, meaning that values in the series are influenced by long-term dependencies. Such behavior indicates that the original series contains underlying trends or seasonality, making it unsuitable for time series analyses that require stationarity. By differencing, these trends can be removed, helping to stabilize the mean and make the series appropriate for further analysis

Figure 1.5:- Autocorrelation Function (At First Difference)

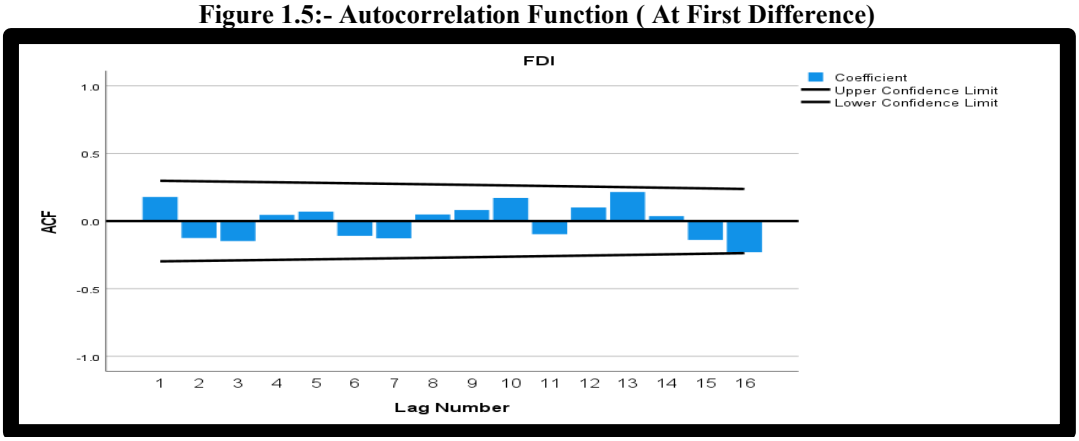


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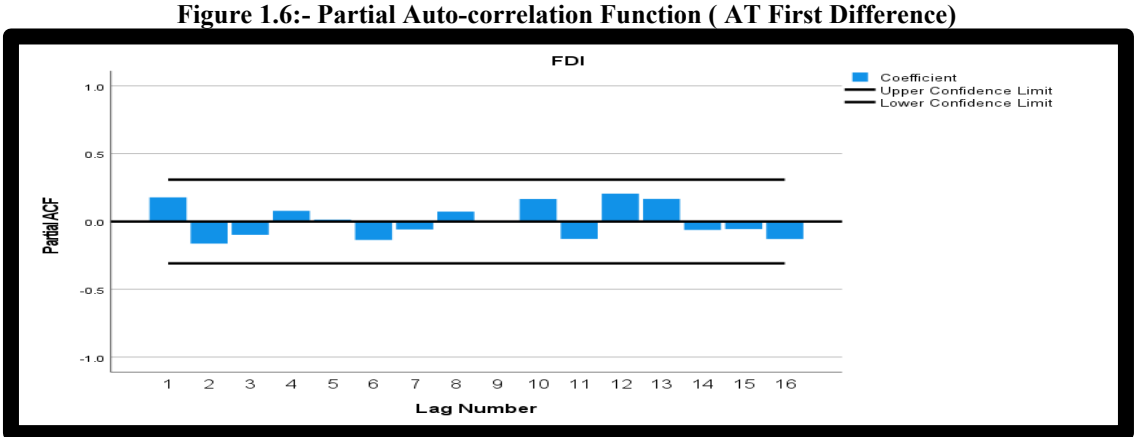
Figure 1.6:- Partial Auto-correlation Function (AT First Difference)



The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the differenced data confirm stationarity at the first difference, as both plots show no significant autocorrelations beyond the initial lags. This outcome indicates that the series is now free from trends and seasonal patterns that could otherwise bias the analysis. With the data achieving stationarity at first difference, it is well-suited further modeling and analysis.The ARIMA model, labeled FDI-Model_1, follows the Box-Jenkins methodology and demonstrates high predictive accuracy for forecasting Foreign Direct Investment (FDI) in India, as indicated by an R-squared value of 0.968. This high R-squared value suggests that FDI-Model_1 explains approximately 96.8% of the variance in FDI, reflecting a strong model fit.

Table 1.4:- ARIMA Model Coefficients and Statistics

FDI-Model_1			Estimate	SE	t-statistics	Sig.
		Constant	1780.364	847.742	2.100	.043
	AR	Lag 1	.282	.383	.736	.467
		Lag 2	-.916	.323	-2.834	.007
	Difference (1)					
	MA	Lag 1	.136	.460	.296	.769
		Lag 2	-.800	.386	-2.072	.045

The ARIMA model (FDI-Model_1) for forecasting Foreign Direct Investment (FDI) in India includes statistically significant parameters, enhancing its predictive accuracy. The constant term, with an estimate of 1780.364 and a significance level of .043, is statistically significant, suggesting a stable mean level of FDI in the model. Among the autoregressive (AR) terms, Lag 2 is significant with a p-value of .007, indicating that past FDI values at this lag contribute meaningfully to the model's predictions. The moving average (MA) term for Lag 2 is also significant with a p-value of .045, capturing short-term fluctuations effectively. These statistically significant components confirm that FDI-Model_1 has successfully identified relevant past influences, leading to a reliable model fit for FDI forecasting.

VII. Conclusions

This study aims to forecast Foreign Direct Investment (FDI) trends in India using the ARIMA (2,1,2) model with data sourced from the Reserve Bank of India spanning 1981 to 2023. The ARIMA model, based on the Box-Jenkins methodology, allows for the identification of autoregressive (AR), moving average (MA), and differencing (I) components to effectively capture patterns in FDI data. The model's performance will be evaluated using diagnostic tests such as the Ljung-Box Q-test for autocorrelation in residuals and R-squared values to assess the goodness of fit, with a target of achieving an R-squared above 90%. Post-estimation validation, including out-of-sample testing, will help ensure the model's robustness and forecasting accuracy. This research aims to provide valuable insights for policymakers and investors by offering a clear projection of FDI trends, while also suggesting

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the potential for further enhancements through the inclusion of macroeconomic variables and alternative forecasting methods.

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