

## **Foreign Direct Investment and Economic Growth in Nepal: Evidence from ARDL and ARIMA Forecasting Models**

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### **ABSTRACT**

This study investigates the relationship between foreign direct investment (FDI) and economic growth in Nepal using annual time-series data from 1960 to 2024. Employing the Autoregressive Distributed Lag (ARDL) bounds testing approach, the analysis examines both short-run dynamics and long-run equilibrium relationships between GDP growth and FDI. The empirical results reveal that FDI does not exert a statistically significant effect on economic growth in the short run. However, the bounds test confirms the existence of a stable long-run cointegrating relationship between FDI and GDP growth. The estimated error correction model indicates rapid adjustment toward long-run equilibrium, suggesting that deviations caused by short-term shocks are corrected swiftly, albeit with evidence of overshooting behavior. Structural break analysis further identifies regime changes in Nepal's growth trajectory. To assess predictive performance, the forecasting accuracy of the ARDL model is compared with that of an ARIMA framework using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). The results indicate that the ARDL model provides marginally superior forecasting accuracy relative to the ARIMA model. Overall, the findings suggest that while FDI does not stimulate immediate economic growth in Nepal, its long-run contribution depends critically on domestic absorptive capacity, institutional quality, and policy stability.

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**Keywords:** Foreign Direct Investment; Economic Growth; ARDL; ARIMA; Forecasting, MAE, RMSE.

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## 1. Introduction

Foreign Direct Investment (FDI) has traditionally been viewed as the part of the development policy in emerging and developing economies. It has been attributed to offer capital inflows, transfer of technology, provision of employment, and incorporation of host nations in global production lines. (Balami et al., 2024; Dahal et al., 2024; Pradhan, 2017; Rao et al., 2023; Singh and Pradhan, 2023).

The effectiveness of FDI has been a subject of continued scholarly debate in South Asia. India and Sri Lanka have received relatively higher inflows, but Nepal has been a modest and irregular receiver of the FDI inflows, which is indicative of policy constraints as well as policy bottlenecks (Bhattarai, 2009; Kharel, 2012). In Nepal, policymakers often view FDI as a key instrument for alleviating resource constraints and stimulating economic growth. However, empirical studies focusing on Nepal frequently report weak or statistically insignificant short-run effects of FDI on economic growth (Budha, 2012; Das and Sethi, 2020; Phuyal and Sunuwar, 2018). At the same time, several studies document the presence of long-run associations between FDI and economic growth, suggesting that the potential benefits of foreign investment may materialize gradually over time rather than immediately (Adhikary, 2017; Chhetri, 2022; Pokhrel and Khadka, 2019).

Despite the growing body of literature, several gaps remain in the Nepalese context. First, much of the existing research relies on linear time-series frameworks and provides limited insight into the adjustment dynamics between FDI and economic growth over time. Second, although absorptive capacity is frequently emphasized in the literature, it is often discussed conceptually rather than examined within a unified empirical framework. Third, comparative evidence on the forecasting performance of structural models incorporating macroeconomic fundamentals and non-structural time series models remains limited in South Asian studies, despite its relevance for policy-oriented analysis (Das and Sethi, 2020; Rao et al., 2023).

The present study examines the dynamic relationship between FDI and economic growth in Nepal using the Autoregressive Distributed Lag (ARDL) bounds testing approach, which allows for the analysis of both short-run and long-run dynamics within a single framework. The analysis is complemented by an error correction mechanism and structural break diagnostics to capture adjustment behavior and regime changes in economic growth. In addition, the study compares the forecasting performance of ARDL-based regressions with Autoregressive Integrated Moving Average (ARIMA) models using standard accuracy measures such as Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). By doing so, the paper contributes to a clearer understanding of the FDI–growth relationship in Nepal and offers insights relevant for other emerging economies facing similar developmental challenges.

## 2. Methodology

### Data and Variables

**Data and Variables** This study utilizes annual time series data for Nepal, covering the period 1960-2024. The dependent variable is GDP growth (annual %), while the primary independent variable is Foreign Direct Investment (FDI, % of GDP). To capture absorptive capacity, two composite indices Human Capital Index which is based on literacy rate, tertiary enrollment, and life expectancy following Adhikary (2017); Budha (2012); Phuyal and Sunuwar (2018) and Health Infrastructure Index (HII) which is based on health expenditure and under five mortality in line with Chhetri (2022); Pokhrel and Khadka (2019) has been used. Control variables include trade openness (% of GDP), gross capital formation (% of GDP), and government final consumption expenditure (% of GDP), consistent with prior studies on FDI growth dynamics done by Agrawal (2000); Athukorala (2003); Bhattarai (2009).

### Unit Root and Stationarity Tests

Prior to model estimation, the time-series properties of the variables were examined to determine their order of integration. Stationarity was tested using both the Augmented Dickey–Fuller (ADF) test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. The ADF test evaluates the null hypothesis of a unit root, whereas the KPSS test examines the null hypothesis of stationarity. Employing both tests provides complementary evidence on the stochastic properties of the series.

This step is essential for the application of the Autoregressive Distributed Lag (ARDL) bounds testing approach, which allows regressors to be integrated of order zero or one,  $I(0)$  or  $I(1)$ , but not of order two,  $I(2)$  (Pesaran et al., 2001). The combined use of ADF and KPSS tests helps ensure that none of the variables violate this requirement, consistent with recent empirical studies (Das and Sethi, 2020; Singh and Pradhan, 2023).

The ADF regression model is specified as follows:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^p \delta_i \Delta y_{t-i} + \varepsilon_t \quad (2.1)$$

where  $y_t$  denotes the variable under examination,  $t$  represents a deterministic time trend,  $p$  is the optimal lag length selected based on information criteria such as AIC or BIC, and  $\varepsilon_t$  is a white-noise error term.

### ARDL Bounds Testing and Error Correction

To examine the dynamic relationship between foreign direct investment and economic growth in Nepal, the Autoregressive Distributed Lag (ARDL) modeling approach was employed. The ARDL framework allows for the analysis of short-run dynamics and long-run associations

among variables, irrespective of whether the regressors are integrated of order zero or one, provided none is integrated of order two.

The existence of a long-run relationship between GDP growth and foreign direct investment was tested using the bounds testing procedure developed by Pesaran et al. (2001). Where evidence of cointegration was found, an Error Correction Model (ECM) was estimated to capture short-run adjustments toward the long-run equilibrium, following the approach adopted in Srinivasan et al. (2011) and Masipa (2014).

The general ARDL( $p, q$ ) model is specified as follows:

$$Y_t = \alpha_0 + \sum_{i=1}^p \alpha_i Y_{t-i} + \sum_{j=0}^q \beta_j X_{t-j} + u_t \quad (2.2)$$

where  $Y_t$  denotes GDP growth,  $X_t$  represents foreign direct investment,  $p$  and  $q$  are the optimal lag orders selected using standard information criteria, and  $u_t$  is a white-noise error term.

Upon establishing cointegration, the short-run dynamics were estimated using an Error Correction Model (ECM)

$$\Delta Y_t = \phi_0 + \sum_{i=1}^{p-1} \phi_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \theta_j \Delta X_{t-j} + \lambda ECT_{t-1} + \varepsilon_t \quad (2.3)$$

where  $ECT_{t-1}$  is the lagged error correction term derived from the long-run relationship,  $\lambda$  represents the speed of adjustment toward equilibrium, and  $\varepsilon_t$  is a white-noise disturbance term. A negative and statistically significant value of  $\lambda$  indicates convergence toward the long-run equilibrium following short-run shocks.

### ARDL(1,1) Estimation and Error Correction Framework

Based on the optimal lag selection criteria, an Autoregressive Distributed Lag model of order one, ARDL(1, 1), was estimated to examine the dynamic relationship between foreign direct investment and economic growth in Nepal. The ARDL(1, 1) specification is expressed as:

$$GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 FDI_t + \beta_3 FDI_{t-1} + \varepsilon_t \quad (2.4)$$

where  $GDP_t$  denotes annual GDP growth (in percentage terms),  $FDI_t$  represents foreign direct investment as a percentage of GDP, and  $\varepsilon_t$  is a white-noise error term. The inclusion of one lag of GDP growth and one lag of FDI allows the model to capture dynamic adjustment effects.

Following the establishment of a long-run relationship using the ARDL bounds testing approach, the short-run dynamics were modeled through an error correction representation de-

rived from the ARDL(1, 1) framework:

$$\Delta GDP_t = \phi_0 + \sum_{i=1}^{p-1} \phi_i \Delta GDP_{t-i} + \sum_{j=0}^{q-1} \theta_j \Delta FDI_{t-j} + \lambda ECT_{t-1} + u_t \quad (2.5)$$

where  $ECT_{t-1}$  is the lagged error correction term obtained from the estimated long-run equilibrium relationship,  $\lambda$  measures the speed of adjustment toward the long-run equilibrium, and  $u_t$  is the short-run disturbance term. A negative and statistically significant value of  $\lambda$  indicates convergence toward equilibrium following short-run shocks.

### Diagnostic, Forecasting and Software

To assess potential multicollinearity among regressors, pairwise correlation analysis was performed, followed by the computation of Variance Inflation Factors (VIF). The VIF for each regressor was calculated as:

$$VIF_j = \frac{1}{1 - R_j^2} \quad (2.6)$$

where  $R_j^2$  denotes the coefficient of determination obtained from regressing the  $j$ th explanatory variable on the remaining regressors (Pradhan, 2023). VIF values below the conventional threshold indicate the absence of serious multicollinearity, confirming the suitability of the regressors for inclusion in the ARDL model. These diagnostic procedures follow the approaches adopted by Pandey et al. (2024) and Dahal et al. (2024).

All models were estimated using the R statistical environment. The ARDL and dynamic regressions were implemented using the ARDL and dynlm packages, while time-series forecasting was conducted using the forecast package. Missing observations were handled through interpolation using the zoo package. To address potential heteroskedasticity and autocorrelation, robust standard errors were computed using the sandwich estimator. Optimal lag lengths were selected based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) minimization, consistent with Athukorala (2003) and Sahoo (2006).

For predictive validation, out-of-sample forecasts generated from the ARDL-based regression model were compared with forecasts obtained from an AutoRegressive Integrated Moving Average (ARIMA) model. Forecast accuracy was evaluated using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), defined respectively as:

$$MAE = \frac{1}{T} \sum_{t=1}^T |Y_t - \hat{Y}_t| \quad (2.7)$$

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^T (Y_t - \hat{Y}_t)^2} \quad (2.8)$$

where  $Y_t$  denotes the actual value,  $\hat{Y}_t$  represents the forecasted value, and  $T$  is the number of forecast observations. The use of these indicators is consistent with the comparative forecasting

frameworks adopted in Das and Sethi (2020), Pradhan and Koirala (2024), Rao et al. (2023), Upadhyay and Pradhan (2023).

### 3. Result

#### Unit Root and Stationarity Diagnostics

To assess the suitability of the ARDL bounds testing framework, the stationarity properties of the variables were examined using the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The ADF test rejects the null hypothesis of a unit root for GDP growth at the 1% significance level (ADF statistic = -6.72, which is lower than the 1% critical value of -3.51), indicating that GDP growth is stationary in levels, that is, integrated of order zero,  $I(0)$ .

The KPSS test, which evaluates the null hypothesis of stationarity, yields a test statistic of 0.611 with a p-value of 0.021, leading to the rejection of the null at conventional significance levels. While this provides some evidence against level stationarity, the overall results considering the strong ADF evidence support treating GDP growth as an  $I(0)$  process. Such mixed evidence is common in applied time-series analysis and does not preclude the use of the ARDL bounds testing approach, which accommodates variables integrated of order  $I(0)$  or  $I(1)$ .

To assess the suitability of the Autoregressive Distributed Lag (ARDL) bounds testing framework, the stationarity properties of the variables were examined using the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The ADF test evaluates the null hypothesis of a unit root, whereas the KPSS test examines the null hypothesis of stationarity.

#### ARDL Estimation

An ARDL(1, 1) model was estimated with GDP growth as the dependent variable and foreign direct investment (FDI) as the explanatory variable. Table 1 reports the estimated coefficients.

**Table 1:** ARDL(1, 1) Model Estimation Results

Variable	Coefficient	Std. Error	<i>t</i> -value	<i>p</i> -value
Intercept	5.1789	0.7403	6.996	< 0.001
Lag(GDP growth)	-0.2526	0.1497	-1.687	0.099
FDI	-0.2524	2.5638	-0.098	0.922
Lag(FDI)	1.6945	2.4800	0.683	0.498

The ARDL(1, 1) results indicate that the lagged dependent variable is marginally significant at the 10% level ( $p = 0.099$ ), suggesting limited persistence in GDP growth dynamics. However, both the contemporaneous and lagged coefficients of FDI are statistically insignificant ( $p = 0.922$  and  $p = 0.498$ , respectively), indicating that FDI does not exert a significant short-run

effect on economic growth.

The model exhibits a low adjusted  $R^2$  value of 0.0097, and the overall  $F$ -statistic is statistically insignificant ( $p = 0.344$ ), implying weak short-run explanatory power. These findings are consistent with the view that the growth-enhancing effects of FDI may not materialize immediately but may operate through long-run channels.

### Bounds Testing for Cointegration and Error Correction

Although the short-run coefficients obtained from the ARDL estimation are weak, the bounds testing procedure provides strong evidence of a long-run relationship between foreign direct investment (FDI) and GDP growth in Nepal. The computed  $F$ -statistic ( $F = 35.05$ ,  $p$ -value  $< 0.001$ ) exceeds the upper critical bound at the 1% significance level, leading to the rejection of the null hypothesis of no cointegration. This result provides strong evidence of a long-run equilibrium relationship between FDI and economic growth.

Following the confirmation of cointegration, an Error Correction Model (ECM) was estimated to capture short-run dynamics and the speed of adjustment toward the long-run equilibrium. The estimated error correction term ( $ECT_{t-1}$ ) is negative and highly statistically significant ( $-1.25$ ,  $p < 0.001$ ), indicating rapid adjustment toward long-run equilibrium after short-run shocks. Specifically, approximately 125% of the previous period's disequilibrium is corrected within one year, suggesting an overshooting adjustment mechanism. An error-correction coefficient exceeding unity in absolute value indicates an overshooting adjustment mechanism, which may arise due to policy delays, structural rigidities, or volatility in capital inflows."

In contrast, the short-run impact of changes in FDI on GDP growth remains statistically insignificant ( $\Delta FDI$  coefficient =  $-0.44$ ,  $p = 0.844$ ), reinforcing the view that the growth effects of FDI in Nepal materialize primarily over the long-run.

The ECM demonstrates strong explanatory power, with an adjusted  $R^2$  of 0.624, and the overall model is statistically significant as indicated by a highly significant  $F$ -statistic ( $p < 0.001$ ). These findings confirm the robustness and validity of the estimated error correction framework.

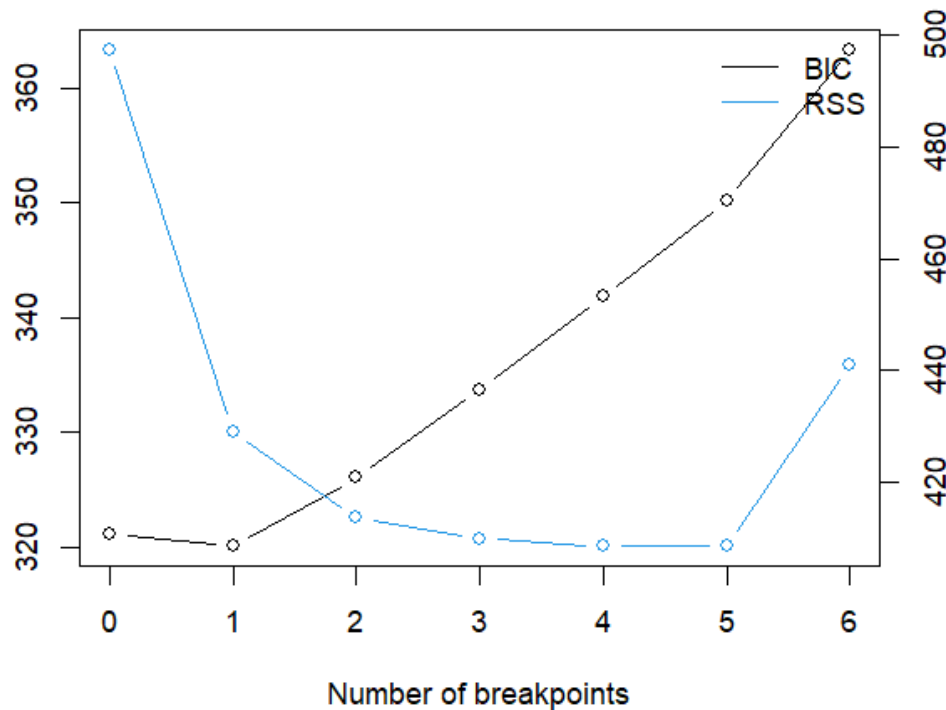
**Table 2:** Error Correction Model (ECM)

Variable	Coefficient	Std. Error	t-value	p-value	Significance
Intercept	0.1126	0.4064	0.277	0.783	
$\Delta FDI$	-0.4392	2.2195	-0.198	0.844	
$ECT_{t-1}$	-1.2514	0.1477	-8.473	$1.5 \times 10^{-10}$	***

Note: \*\*\* denotes statistical significance at the 1% level.

### Structural Break Analysis.

The Bai-Perron multiple breakpoint test was employed to detect potential structural changes in the GDP growth series. Breakpoints were selected by minimizing the Bayesian Information Criterion (BIC). The lowest BIC value (320.1) was obtained at  $m = 1$ , indicating the presence of a single optimal structural break in the series.



**Figure 1:** BIC and Residual Sum of Squares

Although the Residual Sum of Squares (RSS) continued to decline with the inclusion of additional breakpoints, it began to increase beyond  $m = 5$ , suggesting potential overfitting. This pattern supports the principle of parsimony and confirms that a single structural break adequately captures regime shifts in Nepal's GDP growth dynamics.

### Collinearity Diagnostics

To assess potential multicollinearity among the explanatory variables, pairwise correlation analysis and Variance Inflation Factors (VIF) were computed. Table 3 reports the correlation matrix among Foreign Direct Investment (FDI), trade openness, and gross capital formation.

**Table 3:** Collinearity Diagnostics: Correlation Matrix and Variance Inflation Factors

Variable	Correlation Matrix			VIF
	FDI	Trade	Capital Formation	
FDI (% of GDP)	1.00	0.48	0.66	1.79
Trade (% of GDP)	0.48	1.00	0.68	1.91
Capital Formation (% of GDP)	0.66	0.68	1.00	2.63

The correlation coefficients indicate moderate associations among the regressors; however,

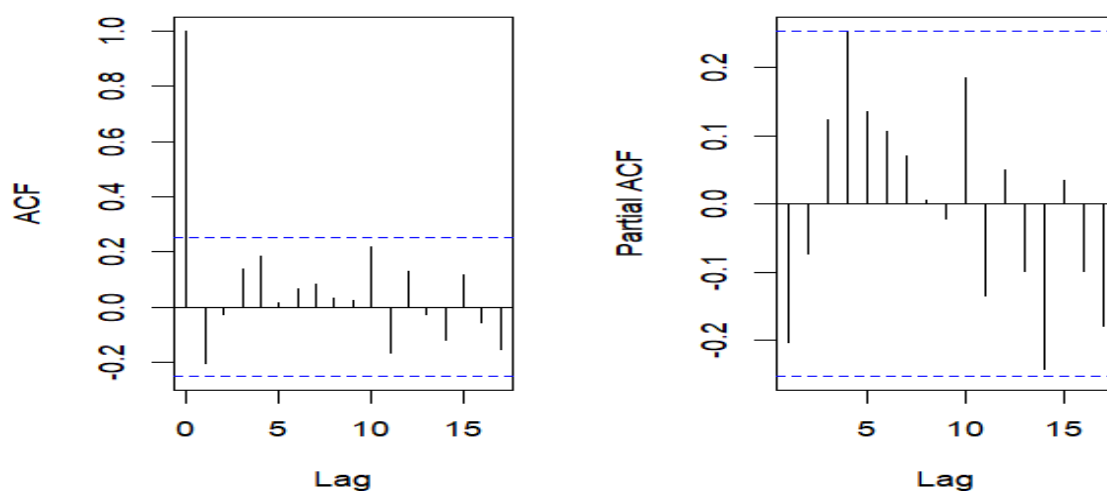
none exceed the commonly accepted threshold of 0.80, suggesting the absence of severe multicollinearity. To further validate this finding, VIF values were calculated and are reported in Table 3. All VIF values are well below the critical value of 5, confirming that multicollinearity does not pose a concern for the ARDL estimation.

### ARIMA Model

To evaluate predictive performance, several ARIMA specifications were estimated and compared using the mean absolute error (MAE) and root mean square error (RMSE). Table 4 presents the forecast accuracy measures along with brief descriptions of each model. Among the competing specifications, ARIMA(0,1,1) achieved the lowest forecast error (MAE = 1.205, RMSE = 1.384), indicating superior predictive performance. This was followed by ARIMA(2,1,0) (MAE = 1.249, RMSE = 1.447). In contrast, ARIMA(1,1,1) and ARIMA(0,1,2) produced higher forecast errors, suggesting weaker predictive ability. Overall, the results indicate that parsimonious specifications such as ARIMA(0,1,1) provide a more reliable fit for Nepal's GDP growth series than more complex alternatives.

**Table 4:** Performance Comparison of ARIMA Models

Model	MAE	RMSE	Interpretation
ARIMA(0,1,1)	1.205	1.384	Best performing ARIMA model
ARIMA(2,1,0)	1.249	1.447	Second best, moderate accuracy
ARIMA(1,1,1)	1.801	1.944	Higher forecast error
ARIMA(0,1,2)	1.985	2.229	Weakest fit, least accurate



**Figure 2:** ACF and PACF correlogram

The ACF plot shows a significant spike at lag 1, followed by a rapid decline with no significant autocorrelations at higher lags. In contrast, the PACF does not exhibit a clear cutoff and instead displays a gradual decay. This pattern is characteristic of an MA(1) process. Consequently, after first differencing, the ARIMA(0,1,1) model is appropriate for capturing the underlying

dependence structure. The lack of significant autocorrelation beyond the first few lags indicates that higher-order AR or MA terms are unnecessary, making ARIMA(0,1,1) a parsimonious and statistically adequate specification.

### Comparison of ARDL and ARIMA

The forecasting performance of the simplified ARDL model and the ARIMA(0,1,1) model is compared using MAE and RMSE. The results indicate that the simplified ARDL model exhibits marginally superior forecasting accuracy than the ARIMA model, as it records lower MAE and RMSE shown in table 5 . Although the gap in forecast accuracy between the two models is not

**Table 5:** Forecast Accuracy Comparison: ARDL vs. ARIMA

Model	MAE	RMSE	Interpretation
ARDL (Simplified)	1.192	1.370	Lower forecast error
ARIMA(0,1,1)	1.205	1.384	Higher forecast error

large, the ARDL model performs slightly better, indicating that including relevant macroeconomic variables helps improve GDP growth predictions. Unlike ARIMA, which depends only on past values of the series, the ARDL approach captures underlying economic relationships. Overall, the results suggest that even modest gains in short-term GDP growth forecasts can be achieved when structural economic information is incorporated through the ARDL framework.

## 4. Discussion

The findings show that FDI has no statistically significant short-run effect on the growth of the GDP of Nepal in its current or lagged form. The signs of the coefficients indicate little and inconsistent effects, and even the current FDI term is exhibiting a negative but statistically insignificant association. Conversely, the lagged GDP growth variable is marginally significant, hence existence of some level of persistence in the growth dynamics. This conclusion is consistent with the general body of literature that highlights the conditionality of the effectiveness of FDI, in which the institutional quality, absorptive capacity, and structural readiness is what defines whether foreign investment leads to growth (Athukorala, 2003; Srinivasan et al., 2011). The lack of short-run significance supports the previous research Budha (2012) and Phuyal and Sunuwar (2018) that states that FDI gains in Nepal are more prone to be achieved in the long-term, as long as the country is able to improve its human capital, infrastructure, and governance aspects. Although insignificant in the short-run, the ARDL bounds test and ECM findings determine a strong long-term equilibrium between FDI and GDP growth and fast movement to the equilibrium point. This is in line with the absorptive capacity theory and it holds the opinion that FDI only helps in growth when the capabilities of the country are enhanced (Masipa, 2014; Sahoo, 2006). Structural break analysis also helps to identify the change of regimes in the development path of Nepal with a need to have segmented approaches to policies. The comparisons in forecasting indicate that ARDL model is better in

predictive accuracy than ARIMA. This adds to the role of fundamentals in prediction is in line with Adhikary (2017) and Pokhrel and Khadka (2019) Adhikary (2017) and Pokhrel and Khadka (2019) which explains the volatility of growth in Nepal by factors of macroeconomic determinants. The findings indicate that FDI has no significant effect on short-run growth, but it still is applicable in the long-run, as long as Nepal enhances its absorptive capacity. This can be compared to the recent work by highlighting the importance of human capital, institutional mechanisms, and structural reforms as the conditions of how to translate external inflows into the long-term growth (Chhetri, 2022; Dahal et al., 2024; Mahara, 2022).

## 5. Conclusion

In this paper, FDI is not considered to have a significant effect on the growth of the Nepal GDP in the short term, but the equilibrium relationships in the long term affirm its significance. The robust error correction mechanism suggests that the correction of deviations are rapidly corrected and this supports the role of FDI in long-term growth. Structural break analysis also indicates that there are regime shifts in the growth path of Nepal which indicates that growth results are determined by the evolving domestic and international conditions. It has been demonstrated that FDI is not enough to spur growth in Nepal. They rely on the abilities to enhance the absorption capacity, institutional quality and structural change. Under the condition that there are no strong domestic capabilities, FDI inflows are neutral in the short-run and only play a significant part in the long-run. On policy front, Nepal needs to focus on investing in education, health infrastructure and institutional reforms that will boost the absorptive capacity. Increased governance and regulatory systems will make possible that FDI inflows will be channeled into productive sectors. Meanwhile, hydropower, agricultural, and tourism should also be exploited to make the most of the long-run advantages of openness and external capital. With its attention to these areas, Nepal will be able to turn FDI into an impartial inflow that can lead its economic growth and development in a sustained and inclusive way.

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