

Technological Innovation, External Debt, and Sustainable Economic Growth: Evidence from India

Spoorthi G. Hadimani*, Basavaraj M. S.

Department of Economics Studies and Planning, Central University of Karnataka, Kalaburagi, India

*Corresponding Author: hadimanispoorthi@gmail.com

Information of Article

Article history:

Received: 01 July 2026

Presented: 22 August 2026 (INSPIRE-2026, GIBS Bengaluru)

Keywords:

Technological Innovation

External Debt

Sustainable Economic Growth

Trade Openness

ARDL bounds testing approach

ABSTRACT

The paper aims to analyse the dynamics of technological innovation, sustainable economic growth, FDI, external debt, inflation, and trade in India spanning 1990 to 2024. The ARDL technique is taken because all the variables namely GDP, inflation, external debt, technological innovation, FDI and trade openness are determined to be mixed integration order by the tests of unit root. In this empirical analysis, the short and long run response functions are evaluated with the help of ECM. Empirical results show, in the analyses of long run, the selected variables are cointegrated. In the growth model, external debt, technological innovation and trade are significantly and positively related with sustainable expansion in the long run while consumer price and FDI exert a adverse but not significant relationship with the sustainable growth. The external debt model suggests that FDI is a major factor in lowering external debt, whereas inflation and technological innovation are important long-run factors. Some of the conclusions derived from the results indicate that the technological innovation needs to be enhanced, productive utilization of external borrowing has to be encouraged and trade integration and macroeconomic stability are vital for long-term economic progress in India. The study outlines the bidirectional connection between economic development and overseas debt using a single framework of ARDL, and provides the practical policy suggestions for external debt management and innovation-based economic growth.

How to cite: Spoorthi G. Hadimani & Basavaraj M. S. (2026). Technological Innovation, External Debt, and Sustainable Economic Growth: Evidence from India. *Journal of Reproducible Research*, 1(2), Special Issue: INSPIRE-2026, pp. 54–65.

1. Introduction

Technology innovation is now a crucial component of macroeconomic stability and prosperity in both developed and emerging nations. The World Bank (2024) reports that, GDP increased by around 3.2% globally in 2023, and nations with higher levels of productivity and technical advancement demonstrated greater resilience to external economic shocks. Concurrently, foreign debt is crucial for funding industrial growth, infrastructure, and structural change, especially in developing nations when domestic savings is insufficient. The Report of World Bank (2024) projects, the foreign debt stock of low- and middle-income nations will exceed US\$8.8 trillion in 2023 due to this rise (Huang & Wang, 2026). However, the loan's economic return will rely on how well it is used and directed toward initiatives that promote economic growth. Furthermore, it is currently projected that 63% of the GDP of world is open to trade; this growth in trade opening has led to market integration, technological diffusion, and export competitiveness. Simultaneously, inflows in foreign direct investment (FDI) have increased to a projected US\$1.5 trillion in 2023 (UNCTAD, 2024), facilitating the transfer of technological and the development of capital and productivity enhances in the host countries. Stable inflation also encourages more investment, which lowers macroeconomic uncertainty and helps to properly channel resources. In the context of its effects on long-term economic growth and external financial stability, the connections between technological innovation and external debt, between economic growth and openness, between FDI and inflation, and between the two are becoming a major area of interest in current macroeconomic policy.

The Endogenous (Romer, 1990) postulates, technological advancement promotes productivity growth, capital accumulation, and long-term economic growth, provides the basis for our investigation. Debt Overhang Theory (Krugman, 1988) states that growth can benefit from foreign borrowing as long as it is not excessive; if it is, investment and economic performance would be constrained. According to the Trade-Led Growth hypothesis (Grossman & Helpman, 1991), trade openness increases the likelihood of technology transfer and export competitiveness. The Eclectic (OLI) Theory (Dunning, 1988) can explain the rise and relaxation of financial limitations and FDI as well as the transfer of capital and technology. Additionally, the Phillips curve illustrates the association between macroeconomic stability, investment, and inflation, all of which affect economic growth and external borrowing.

For both sustained economic growth and macroeconomic stability, India's economic development policy has placed an increasing emphasis on technological innovation. Since economic liberalisation in 1991, India has become more actively integrated in worldwide networks since increasing technology transfer and productivity enhancement through enhanced trade liberalism and liberalised FDI standards. India's real GDP increased by 8.2% in FY2023–2024, making it one of the world's most rapidly developing largest economies (NSO, First Revised Estimates, 2025) and is expected to expand by around 7.0% in FY2024–2025 (World Bank, India Development Update, 2025). At the same time, FDI inflows, projected at US\$81 billion in FY2024–2025 (FDI Fact Sheet, 2025, DPIIT), continued to be robust and investor confidence has remained high worldwide. Similarly, increased trade openness and FDI inflows have improved competitiveness and facilitated knowledge transfer (Grossman & Helpman, 1991; Borensztein et al., 1998). As of December 2024, India's foreign debt was estimated to be approximately \$718 billion, with foreign debt to GDP ratio of about 18.7% (RBI, India's foreign Debt Report, 2025). This indicates an acceptable level of external vulnerability on a global scale. The macroeconomic climate for investment and capital formation has improved as inflation has been steadily approaching the Reserve Bank of India's target range over the past few years, with the Consumer Price Index (CPI) averaging 4.6% for the fiscal year 2024–2025 (RBI, Annual Report 2024–2025). Despite these successes, India is still far from advancement in technology, foreign investment, trade liberalisation, and capital inflow to boost productivity and lessen reliance on borrowing from outside sources. In this contemporary policy environment, it is crucial to explore the connections among technological innovation and external debt, economic development, trade openness, inflation, and fdi within a single empirical policy framework.

In India, the role of innovation, ICT adoption, R&D, and digital transformation in growth is often overlooked in favour of macro-economic interactions. (Maheshwari & Loke, 2024; Erumban & Das, 2016; Rooj & Kaushik, 2024). The existing body of work on the impact of external debt on economic growth has focused on the direct effects of external debt on the economy, and largely ignored the relationship between technology innovation, foreign direct investment, trade openness and inflation in a more comprehensive empirical analysis. While much work has been done on the impact of external debt on growth, this research has typically focused on the direct link without taking other important relationships into account. Additionally, the majority of earlier research has concentrated on the unidirectional relationship in which foreign debt is viewed as a dependent variable; modelling external debt as an independent variable and its effect on economic development have received very less attention. Furthermore, only a small number of studies have examined the other side of the equation, modelling the external debt as the dependent variable and the impact of external debt on economic growth as the independent variable. The majority of studies have been carried out from a forward-looking perspective, that is, by defining the dependent variable as economic growth. The purpose of this study is to examine the impact of technological innovation on India's economic growth and its external debt from the year 1990 up to 2024. The study also applies the ARDL bounds testing approach to analyze both the short-term and long-term connections among trade openness, inflation, foreign direct investment, economic growth, foreign debt, and technological innovation.

2. Review of literature

It has been suggested in the literature that sustainable economic growth is a result of combined effects of innovation, external financing, foreign capital, and openness on India's economy, not any single macroeconomic factor (Ahmed

et al., 2026; Halim & Moudud-Ul-Huq, 2024; Maheshwari & Loke, 2024). Endogenous growth theory is the primary explanation of positive role of innovation as technology change, human capital and accumulation of knowledge lead to continuing productivity gains and enhance the LT growth potential (Ahmed et al., 2026; Qamruzzaman & Jianguo, 2018; Qayyum et al., 2025). Over this, open-economy growth theory suggests that the extent of trade openness and international integration can expand market size, enhance efficiency and promote the diffusion of new technologies (Chien et al., 2022; Halim & Moudud-Ul-Huq, 2024).

In this context, the majority of studies in India have shown that innovation is a positive contributor to sustainable growth. Technological innovation directly contributes to long-run growth in India, particularly with the backing of quality education, skills, R&D investments and institutions (Ahmed et al., 2026). Green innovation and green finance also have a positive impact on sustainability-adjusted growth, indicating that the quality and direction of innovation is as important as the quantity (Manigandan et al., 2024; Nenavath & Mishra, 2023). But the evidence is not always encouraging: In India and China, financial innovation has had positive short-run impacts, but has had weak negative longer-term relationships with sustainable growth, suggesting that financial innovation can have a negative relationship or association with efficient resource allocation, especially when it is capital intensive and not conducive to sustainable growth (Qayyum et al., 2025).

Whereas the debt literature is more contentious and can be best understood with the lens of debt overhang theory. At the macro level, this theory suggests that high external debt lowers the motivation to invest as future returns are expected to be used to pay off the debt, and crowding-out theory focuses on a reduction in fiscal space and less productive expenditure (Dawood et al., 2024). This concern is backed up by many studies related to India which have indicated that external debt has a negative impact on growth in the long run, short-run or both (Barik & Sahu, 2022; Kaushik & Lamba, 2026; Roy, 2023). But not all relationships are bad. Several studies do not show any significant long-term impact of debt in India (Kaushik & Lamba, 2026; Ponceno & Indumati, 2023; Gupta & Singh, 2025). This conditional view is further reinforced by cross-country analysis, which identifies the debt thresholds and demonstrates that institutions and savings, along with the efficiency of investment help in mediating the relationship between debt and growth (Biswal & Patra, 2026; Mohsin et al., 2021).

The role of FDI is intermediated and highly conditional in this system. Ideally, FDI should bring technology, capital and managerial expertise, thereby augmenting domestic innovation and minimizing the need for borrowing (Chien et al., 2022; Maheshwari & Loke, 2024). But it is mixed evidence in India. Others, however, have reported negative spillover effects of FDI for innovation growth in the long run (Maitra & Shil, 2024; Ponceno & Indumati, 2023) and weak spillover effects (Maheshwari & Loke, 2024). In contrast, in South Asia, cross-country evidence reveals that FDI can be a booster to growth or a debt reducing force depending upon the effective absorptive capacity and regulatory framework (Kaushik & Lamba, 2026; Ponceno & Indumati, 2023).

The variable that is consistently found to be most supportive of growth in external sector in this literature is trade openness. The literature on BRICS, CIVETS, South Asia and India shows that openness is related to growth in the exports, market size effects and technology access (Halim & Moudud-Ul-Huq, 2024; Kaushik & Lamba, 2026; Mohsin et al., 2021). Meanwhile, there are some cautions about being open, as it may lead to vulnerability, import dependency, or a combination of both if domestic capabilities are low (Chien et al., 2022; Maitra & Shil, 2024).

The literature as a whole suggests that innovation, debt, FDI and openness have a conditionally joint impact on sustainable growth. The most powerful growth-enhancing factor is innovation; trade openness is typically reinforcing; and FDI is enhancing growth when it is used to finance investment that creates productive, innovation-enhancing, and export-augmenting investment processes; and external debt is enhancing growth when it funds investment that is productive, innovation-enhancing, and export-generating, rather than recurrent imbalances or debt-servicing pressures (Ahmed et al., 2026; Dawood et al., 2024; Ponceno & Indumati, 2023; Singh & Kumar, 2024). The overall message for India is that an innovation-led, trade-integrated and wisely managed debt policy will produce the best growth outcomes, with FDI as a complementary and not an automatic driver of growth.

3. Nature of data and methodology

3.1 Data

India's time-series data is used in the present research which is available on an annual basis from 1990 to 2024. Analysis is based on the data on Foreign Direct Investment, net inflows, % of GDP; Inflation, consumer prices, annual %; External debt stocks, % of GNI; Trade % of GDP; and GDP per capita, constant 2015 US\$; Technology innovation. Per capita of GDP is an indicator of economic growth and Patent application, resident is proxy for technology innovation as technology advancement indicator. The datasets are collected from the WDI. Before, empirical investigation the variables are taken in natural logarithm, except FDI.

3.2 Methodology

The primary goal of the research paper is to explore the effect of technology advancement on economic growth and external debt. The study also explores the connection between technology advancement, external debt, inflation, trade openness, economic growth, and FDI inflows. The following equations are used in our study to accomplish these goals:

Model 1: Economic Growth Model

$$\ln \text{GDPPC}_t = \beta_0 + \beta_1 \ln \text{TI}_t + \beta_2 \ln \text{EXDBT}_t + \beta_3 \ln \text{INF}_t + \beta_4 \ln \text{TRADE}_t + \beta_5 \text{FDI}_t + e_t \text{-----}(1)$$

Model 2: External Debt Model

$$\ln \text{EXDBT}_t = \alpha_0 + \alpha_1 \ln \text{TI}_t + \alpha_2 \ln \text{GDPPC}_t + \alpha_3 \ln \text{INF}_t + \alpha_4 \ln \text{TRADE}_t + \alpha_5 \text{FDI}_t + u_t \text{-----}(2)$$

where GDPPC, TI, EXDBT, INF, TRADE, and FDI represents per capita GDP, Technology innovation, external debt, inflation, trade, and net inflows of FDI, respectively. The subscript t, ln, et, and ut represent for the time period, natural logarithm and error terms, respectively, which are considered to be distributed normally and white noise terms. The logarithm conversion was used primarily to modify all of the variables seasonally and to account for the variables' magnitude changes. Additionally, it aided us in interpreting the elasticity term data.

The characteristics of all variables must be analyzed before applying the econometric technique in order to not get wrong results. The Autoregressive Distributed Lag (ARDL) technique verifies the integration characteristics of the variables selected to perform this technique, as the variables should not be an I(2) process, which is problematic and unsuitable for this approach. Phillips-Perron (PP) and The Augmented Dickey-Fuller (ADF) tests are used to check the sequence of variables integration.

To investigate the long-term and short-term relationship between technological innovation, foreign debt and macroeconomic variables in India, we use the ARDL bounds testing technique to integration proposed by Pesaran and Shin (1995) and Pesaran et al (2001). For the following reasons, this strategy is better than other conventional methods of Johansen and Juselius (1990) and Johansen (1991) cointegration. First of all, it is among the most widely used and adaptable techniques. It may be used regardless of the integration order or a combination of both, and it does not impose any restrictions on any type of data. Secondly, compared to other long-run estimations, particularly when the sample size is small, ARDL estimators provide the actual parameters and coefficients, as stated by Pesaran and Shin (1995). Thirdly, it also aids in eliminating the endogeneity issue that arises in the model. Lastly, it can even concurrently collect estimates for the short and long terms. Below are a representation of the unrestricted error correction models (UECM) of the ARDL model for model 1 and 2:

$$\begin{aligned} \Delta \ln \text{GDPPC}_t = & \alpha_l + \alpha_G \ln \text{GDPPC}_{t-1} + \alpha_E \ln \text{EXDBT}_{t-1} + \alpha_T \ln \text{TI}_{t-1} + \alpha_{TR} \ln \text{TRADE}_{t-1} + \alpha_I \ln \\ & \text{INF}_{t-1} + \alpha_F \text{FDI}_{t-1} + \sum_{h=1}^{m_1} \beta_h \Delta \ln \text{GDPPC}_{t-h} + \sum_{i=0}^{n_1} \beta_i \Delta \ln \text{EXDBT}_{t-i} + \sum_{j=0}^{o_1} \beta_j \Delta \ln \text{TI}_{t-j} \\ & + \sum_{k=0}^{p_1} \beta_k \Delta \ln \text{TRADE}_{t-k} + \sum_{l=0}^{q_1} \beta_l \Delta \ln \text{INF}_{t-l} + \sum_{m=0}^{r_1} \beta_m \Delta \text{FDI}_{t-m} + \varepsilon_{1t} \text{-----}(3) \end{aligned}$$

$$\begin{aligned} \Delta \ln EXDBT_t = & \alpha_2 + \alpha_E \ln EXDBT_{t-1} + \alpha_G \ln GDPPC_{t-1} + \alpha_T \ln TI_{t-1} + \alpha_{TR} \ln TRADE_{t-1} + \alpha_I \ln \\ & INF_{t-1} + \alpha_F FDI_{t-1} + \sum_{h=1}^{m_2} \beta_h \Delta \ln EXDBT_{t-h} + \sum_{i=0}^{n_2} \beta_i \Delta \ln GDPPC_{t-i} + \sum_{j=0}^{o_2} \beta_j \Delta \ln TI_{t-j} \\ & + \sum_{k=0}^{p_2} \beta_k \Delta \ln TRADE_{t-k} + \sum_{l=0}^{q_2} \beta_l \Delta \ln INF_{t-l} + \sum_{m=0}^{r_2} \beta_m \Delta FDI_{t-m} + \varepsilon_{2t} \text{-----} (4) \end{aligned}$$

where α_1 and α_2 are the constants; $\beta_h, \beta_i, \beta_j, \beta_k, \beta_l$ and β_m are the short-run coefficients; $\alpha_G, \alpha_E, \alpha_T, \alpha_{TR}, \alpha_I$ and α_F are the long-run coefficients; and ε_t is the error term.

The Akaike Information Criteria (AIC) had been employed to find the most optimum lag. The first stage in developing the ARDL model is to estimate equations 3 and 4 using OLS. The Wald or F test is used to determine the long-run relationship of the variables' lagged values. After determining the long-run connection between the variables, we will utilise the error correction model to study the variables' short-run adjustment speed and dynamics (Samal 2018).

4. Results and discussion

4.1 Tests for Unit root

The integration qualities of variables were tested by the use of the unit root tests of PP and ADF, to ensure that none of the variables had spurious regressions from the non-stationary data. The length of the lag for these tests was again identified through the use of the AIC criterion. The table 1 findings demonstrate inflation (INF) is stationary at level i.e, I (0), while other variables are stationary at first differences i.e, I (1). These results imply that the variables are integrated in a mixed order, I (0) and I (1). As a consequence, we employ the ARDL bounds testing approach to look into the long-term relationship between the variables.

Table 1: Results of Unit Root Test

Variables	ADF (level) t-statistic	Prob.	ADF (first difference) t-statistic	Prob.	PP (level) t-statistic	Prob.	PP (first difference) t-statistic	Prob.
GDPPC	0.960	0.9951	-5.702***	0.0000	1.317	0.9982	-6.541***	0.0000
EXDBT	-1.399	0.5711	-5.987***	0.0000	-1.476	0.5333	-5.986***	0.0000
FDI	-2.206	0.2076	-6.733***	0.0000	-2.191	0.2127	-6.884***	0.0000
INF	-3.439***	0.0173	-7.529***	0.0000	-2.376	1.555	-7.510***	0.0000
TI	1.492	0.9989	-6.178***	0.0000	1.492	0.9989	-6.170***	0.0000
TRADE	-2.189	0.2134	-5.103***	0.0002	-2.189	0.2134	-5.100***	0.0002

Note: *, **, and *** denote the 0.1, 0.05, and 0.01 levels of significance rejection of null. Source: Authors' estimations.

4.2 Cointegration test using ARDL

Table 2: Results of Bound Testing – Bound Testing Approach to Cointegration

Estimated Model	Optimal lag length	F-statistics
$GDPPC = f(EXDBT, FDI, INF, TI, TRADE)$	(1, 3, 3, 0, 1, 3)	4.758
$EXDBT = f(FDI, GDPPC, INF, TI, TRADE)$	(1, 2, 0, 3, 3, 0)	4.532

Critical values: significance level	Lower bound I(0)	Upper bound I(1)
10%	2.508	3.763
5%	3.037	4.443
1%	4.257	6.04

Source: Authors' estimations.

The unit root test indicates that none of the variables are integrated of order 2, and instead they exhibit a mix of zero and one integration. The ARDL bounds test approach is employed to examine long-term relationships in India for the time period from 1990 to 2024. In this context, AIC is employed to identify the most suitable lag length for both models. Table 2 shows that the calculated F-statistic of 4.758 is higher than the upper bound critical values of 3.763 and 4.443 at the 10percent and 5percent significance levels, respectively, when GDPPC is treated as the dependent variable. This indicates that there is a long-run relationship or cointegration among the variables. Similarly, the calculated F-statistic of 4.532 exceeds the upper bound critical values of 3.763 and 4.443 at the 0.1 and 0.05 significance levels, respectively, when EXDBT is used as the dependent variable, suggesting there is a long-run relationship among the variables. This finding suggests that over time, these macroeconomic variables tend to reach a long-term balance and are connected in their development, even though they experience short-term fluctuations. The cointegration relationship aligns with the theoretical framework proposed by Pesaran et al. (2001) and is supported by the estimation of the error correction model and long-run coefficients as discussed in Dey and Tareque (2020).

4.3 Analyses of Long-run and short- run

Table 3: Model 1 Results (Dependent variable: GDPPC)

Variables	Coefficient	t-statistics	p-value
Long-run results			
EXDBT	0.028	2.148**	0.049
FDI	-0.074	-0.823	0.423
INF	-0.148	-1.966*	0.069
TI	0.318	11.864***	0.000
TRADE	0.720	2.639**	0.019
R- squared	0.773		
Short-run results (ECM)			
Constant	0.371	7.018***	0.000
Δ EXDBT	-0.000	-0.449	0.660
Δ EXDBT (-1)	-0.003	-1.631	0.123
Δ EXDBT (-2)	-0.006	-2.882**	0.011
Δ FDI	-0.024	-3.969***	0.001
Δ FDI (-1)	0.008	1.007	0.330
Δ FDI (-2)	0.027	3.414***	0.003
Δ TI	0.001	0.051	0.960
Δ TRADE	0.091	2.242**	0.040
Δ TRADE (-1)	0.016	0.366	0.720
Δ TRADE (-2)	-0.111	-2.980***	0.009
ECT (-1)	-0.230	-6.169***	0.000
Diagnostic tests			
	p-value	F-statistics	
BP test	0.183	1.760	
LM test	0.073	2.431	
Ramsey RESET	0.539	0.398	
Durbin- Waston	1.984		
CUSUM	Stable		
CUSUMSQ	Stable		

Note: *, ** and *** denote the 0.1, 0.05 and 0.01 levels of significance. Source: Authors' estimations.

The substantial correlation between the variables was demonstrated by the ARDL bounds testing method. Nevertheless, the cause-and-effect connections between per capita of GDP, TI, INF, TRADE, FDI, and EXDBT was not revealed by the cointegration test results. Therefore, after examining the long-term association among the variables, we investigate the long-term elasticities of the ARDL bounds testing technique. Table 3 in panel - I show the findings from the long-term study regarding GDPPC, which serves as the dependent variable. In Table 3, an analysis of long-term shows that EXDBT is statistically significantly and positively affected by GDPPC. This implies that a one percent accelerate in EXDBT leads to a corresponding increase in GDPPC by 2.8%, keeping other variables constant. This means that the external borrowing has enabled India to develop its economy by enabling productive investments and by meeting the domestic resource constraints. This positive role, however, relies upon the efficient use and sustainability of borrowed funds; if the debt servicing obligations are too high, it can lower growth at some point (Pattillo et al., 2002). Similarly, TRADE and TI are positively affecting GDPPC at 10%, 5% and 1% significant levels. The findings show that a one percentage rise in TI leads to a 31.8% increase in GDPPC, supporting the endogenous growth theory. This theory emphasizes the role of innovation and the accumulation of knowledge as key drivers of long-term productivity and income growth. Recent empirical evidence also points towards India, which shows that technological advances can have a significant contribution towards improving long-term productivity and economic performance (Ghosh & Parab, 2021). Also, one increase in TRADE induces GDPPC by 72%, *ceteris paribus*, highlighting the importance of the integration with the global markets for growth through technology diffusion, competitiveness and efficient resource allocation, as has been shown in empirical studies of the trade-growth relationship (Irwin & Tervio, 2000). While, INF is negatively affecting GDPPC at 10% significant level, implies one percent increase in INF will reduce GDPPC by 7.4%, keeping variables constant. Whereas, FDI in long-run, is statistically insignificant.

In order to estimate the short-run parameter with speed of adjustment, the ARDL model's last step is error correction. In Table 3, panel-II displays the error correction model's findings. The presence of long-run equilibrium is further supported by the ECM. According to the economic growth model, the EC coefficient shows that about 23% of short-term imbalances are adjusted within one period, and this coefficient is negative and statistically very significant. This shows how quickly adjustments can be made following temporary economic shocks. In an analysis of the short-run results, FDI exerts strong negative and statistically significantly ($\beta = -0.024$, $p = 0.001$) affecting GDPPC, whereas, FDI (-2) becomes positive and significantly ($\beta = -0.027$, $p = 0.003$) impacting GDPPC, reflecting a time lag of FDI's benefits, which will appear in the future, namely through technology transfer and spillovers. Similarly, EXDBT (-2), that is second lag of EXDBT has a adversarial and statistically significant relationship with GDPPC, with a regression coefficient of -0.006 and a p-value of 0.011. Likewise, TRADE is impacting

GDPPC positively and significantly ($\beta = 0.091$, $p = 0.040$), whereas, but its lag of two is significant and negative with coefficient of -0.111 and p value of 0.009. This indicates that there are short-term adjustment challenges associated with trade liberalization, which may hinder the realization of long-term benefits. Technology innovation is included in the selected ARDL model without any short-run lags, meaning its effect is primarily observed through the long-term equilibrium rather than through short-term economic adjustments.

Table 4: Model 2 Results (Dependent variable: EXDBT)

Variables	Coefficient	t-statistics	p-value
Long-run results			
GDPPC	-17.738	-1.128	0.276
FDI	-5.483	-2.670**	0.017
INF	4.189	2.040*	0.058
TI	11.971	1.713*	0.104
TRADE	-1.399	-0.350	0.730
R- squared	0.703		
Short-run results (ECM)			
Constant	25.680	5.947***	0.000
Δ FDI	0.096	0.239	0.814
Δ FDI (-1)	1.108	2.810**	0.012
Δ INF	1.627	2.084*	0.052
Δ INF (-1)	0.913	1.208	0.243
Δ INF (-2)	2.519	3.586***	0.002
Δ TI	-5.984	-2.842**	0.011
Δ TI (-1)	-14.362	-5.052***	0.000
Δ TI (-2)	-14.780	-4.610***	0.000
ECT (-1)	-0.470	-5.932***	0.000
Diagnostic tests			
	p-value	F-statistics	
BP test	0.378	1.072	
LM test	0.1149	2.509	
Ramsey RESET	0.121	2.678	
Durbin- Waston	2.007		
CUSUM	Stable		
CUSUMSQ	Stable		

Note: *, ** and *** denote the 0.1, 0.05 and 0.01 levels of significance. Source: Authors' estimations.

The above table exhibits the findings of the short-run as well as long-run analysis for model 2, where EXDBT is considered as a dependent variable. Panel 1 shows the long-run results, indicating ceteris paribus, one percentage rise in FDI decreases EXDBT by 5.483%. That is FDI is negatively and significantly affecting EXDBT. This conclusion is consistent with earlier studies demonstrating that foreign direct investment works alongside local investments and decreases the reliance on borrowing to fund development efforts (Kumari & Sharma, 2017). Whereas, INF exhibits positive and statistically significant relationship with EXDBT, suggesting one percent increase in INF induces EXDBT by 4.189%. This suggests that prolonged inflation may boost external borrowing through larger fiscal deficits and macroeconomic imbalances. Further, TI shows statistically significant and positively at 0.1 level and TRADE is statistically insignificant in an analysis of long-run.

The ECM explains the dynamics of the short run, where the ECM is statistically significant and negative, implying that roughly 47% of the short-term imbalance is adjusted in a year, showing a quick movement towards long-run equilibrium. The findings also exhibits that lag period in one of FDI shows positive and significantly affecting EXDBT ($\beta = 1.108$, $p = 0.012$) and INF also reveals positive and significantly impacting EXDBT ($\beta = 1.627$, $p = 0.052$) in short-run. Technology innovation (TI) has negative and statistically affecting external debt (EXDBT) in the all lags, that is Δ TI ($\beta = -5.984$, $p = 0.011$), Δ TI (-1) ($\beta = -14.362$, $p = 0.000$), and Δ TI (-2) ($\beta = -14.780$, $p = 0.000$),

showing that advancements in technology boost productivity and strengthen fiscal ability, which in turn reduces the need for borrowing from foreign sources. These results back up the idea that innovation helps a country make better use of its own resources and lowers the need for foreign funding (Romer, 1990).

Tables 3 and 4 demonstrate the diagnostics test results for cointegration using the long-run testing technique. The models do not exhibit non-normality, heteroscedasticity, autocorrelation, or misspecification errors, according to the diagnostic test. Lastly, in order to assess the stability of the models, we ran the CUSUM and CUSUMSQ tests. Figures 1 and 2 exhibit the test results for the same. It means that any model remains stable throughout time.

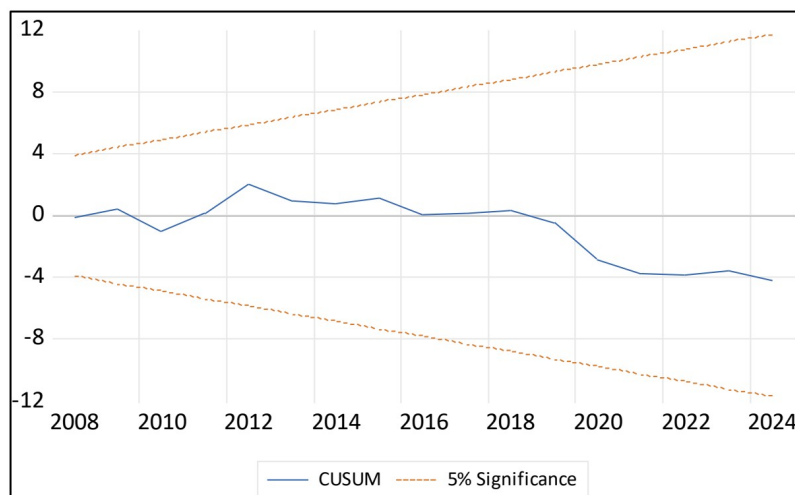


Figure 1: CUSUM test

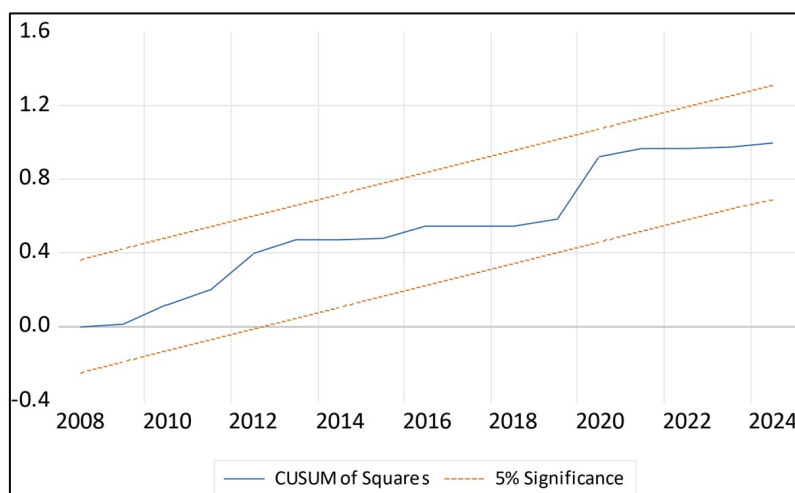


Figure 2: CUSUM SQ test

5. Conclusion and policy implications

The paper investigated the relationship between TI, EXBDT, INF, GDPPC and FDI in India from 1990 to 2024. We have used the ARDL bounds model test in this paper to take into account both the short-run and the long-run study of variables. The ARDL findings demonstrate a long-term association between TI, GDPPC, and EXBDT. The long-run analysis reveals that EXBDT, TRADE and TI have positive and significantly impacting per capita GDP, whereas INF has negative influence on GDPPC and FDI is insignificant in the long-run. While, FDI inflows has negative and significantly affecting EXBDT and INF impacting positively on EXBDT.

Whereas, TI is positive towards EXDBT but significant at 10% level. However, in short-run TI has negative influence on EXDBT in all lag periods.

Empirical results indicate that India's policy must not only be directed towards augmenting the number of external debts taken but also on their productive use. It is important to note that in the long run, external debt has a favourable effect on GDPPC but borrowing should not be considered as a solution to the problem of low GDPPC. Instead, external funding should be channeled into investments that boost productivity, such as investments in climate-resilient initiatives, infrastructure, technological innovation, and human capital development, while continuing to manage the debt in a prudent manner and conducting regular debt sustainability reviews. The role of FDI in lowering external debt is negligible to the long-run economic growth, suggesting larger INFDI may not be enough. Therefore, should be enhanced by increasing skilled human capital, increasing institutional quality and increasing technology spillovers through closer contact between foreign companies and domestic industries. Moreover, the substantial role of technology innovation in the economy emphasises the necessity for continued investment in research and development, digital infrastructure and the protection of intellectual property for the future productivity of the economy. Lastly, the benefits of openness trade argue for export diversification, global value chain participation and improving competitiveness at home, while limiting exposure to external disturbances through diversified export markets and good macroeconomic policy.

Nonetheless, the results have limitations that must be considered. The research relies on yearly data on macroeconomic, and which may influence the relationship between growth and debt, structural changes, institutions and their quality, fiscal governance, and the mix of debt (public versus private debt) are not included. In order to get more comprehensive information, these elements might be included in future projects using either a panel econometric model or a nonlinear econometric model.

References

- Aghion, P., & Howitt, P. (1992). *A model of growth through creative destruction*. *Econometrica*, 60 (2), 323 – 351.
- Ahmed, A., Sharma, D. A., & Shareef, D. M. (2026). *Do Human Capital and Technological Innovation Promote Sustainable Economic Growth in India? Evidence from an ARDL Cointegration Model*.
- Barik, A., & Sahu, J. P. (2022). The long-run effect of public debt on economic growth: Evidence from India. *Journal of Public Affairs*, 22 (1), e2281. <https://doi.org/10.1002/pa.2281>
- Biswal, A. K., & Patra, B. (2026). Debt-Overhang-Reinhart-Rogoff and Exogenous Growth Theory in BRICS Countries. *Review of Development Economics*, 30 (2), 1048 – 1062. <https://doi.org/10.1111/rode.70041>
- Chien, F., Chau, K. Y., Aldeehani, T. M., Huy, P. Q., Tan, L. P., & Mohsin, M. (2022). Does external debt as a new determinants of fiscal policy influence sustainable economic growth: Implications after COVID-19. *Economic Change and Restructuring*, 55 (3), 1717 – 1737. <https://doi.org/10.1007/s10644-021-09365-1>
- Dawood, M., Feng, Z. R., Ilyas, M., & Abbas, G. (2024). External Debt, Transmission Channels, and Economic Growth: Evidence of Debt Overhang and Crowding-Out Effect. *Sage Open*, 14 (3), 21582440241263626. <https://doi.org/10.1177/21582440241263626>
- Department for Promotion of Industry and Internal Trade. (2025). *FDI fact sheet (April 2000 – March 2025)*. Ministry of Commerce and Industry, Government of India. <https://dpiit.gov.in/>
- Ghosh, T., & Parab, P. M. (2021). Assessing India's productivity trends and endogenous growth: New evidence from technology, human capital and foreign direct investment. *Economic Modelling*, 97, 182 – 195. <https://doi.org/10.1016/j.econmod.2021.02.003>
- Dunning, J. H. (1988). The eclectic paradigm of international production: A restatement and some possible extensions. *Journal of International Business Studies*, 19 (1), 1 – 31. <https://doi.org/10.1057/palgrave.jibs.8490372>
- Halim, Md. A., & Moudud-Ul-Huq, S. (2024). Green economic growth in BRIC and CIVETS countries: The effects of trade openness and sustainable development goals. *Heliyon*, 10 (9), e30148. <https://doi.org/10.1016/j.heliyon.2024.e30148>
- Erumban, A. A., & Das, D. K. (2016). Information and communication technology and economic growth in India. *Telecommunications Policy*, 40 (5), 412 – 431. <https://doi.org/10.1016/j.telpol.2015.08.006>
- Goel, R. K. (2010). Foreign direct investment and innovation in India. *The Journal of Developing Areas*, 43 (2), 379 – 390.

- Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. MIT Press.
- Huang, Y., & Wang, M. (Eds.). (2026). *China and Global South development: Economic cooperation, investment, and the “Belt and Road”*. Springer Nature Singapore. <https://doi.org/10.1007/978-981-92-1503-4>
- Irwin, D., & Tervio, M. (2000). *Does Trade Raise Income? Evidence from the Twentieth Century* (No. W7745; p. w7745). National Bureau of Economic Research. <https://doi.org/10.3386/w7745>
- Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: journal of the Econometric Society*, 1551- 1580.
- Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford bulletin of economics & statistics*, 52 (2), 169.
- Kaushik, S., & Lamba, K. (2026). Long and Short-run Reconciliation Between External Debt and Economic Growth: An Empirical Evidence from India. *Journal of Asian Economic Integration*, 8 (1), 98 – 113. <https://doi.org/10.1177/26316846261426756>
- Kumari, R., & Sharma, A. K. (2017). Determinants of foreign direct investment in developing countries: A panel data study. *International Journal of Emerging Markets*, 12 (4), 658 – 682.
- Krugman, P. (1988). Financing vs. forgiving a debt overhang. *Journal of Development Economics*, 29 (3), 253 – 268. [https://doi.org/10.1016/0304-3878\(88\)90044-2](https://doi.org/10.1016/0304-3878(88)90044-2)
- Maheshwari, M., & Loke, R. (2024). The Interplay of Foreign Direct Investment in Unravelling the Nexus of Technological Innovation and Economic Dynamics: An Integrated Study Using Vector Error Correction Model. *The Indian Economic Journal*, 00194662241288041. <https://doi.org/10.1177/00194662241288041>
- Maheshwari, V., & Loke, W. H. (2024). Technology innovation and economic growth: Evidence from India. *Journal of the Knowledge Economy*. Advance online publication. (Update the volume, issue, and page numbers after publication.)
- Maitra, B., & Shil, S. (2024). Investment and Economic Growth in India: Is Foreign Investment Conducive? *Annals of Financial Economics*, 19 (04), 2450016. <https://doi.org/10.1142/S2010495224500167>
- Manigandan, P., Alam, M. S., Murshed, M., Ozturk, I., Altuntas, S., & Alam, M. M. (2024). Promoting sustainable economic growth through natural resources management, green innovations, environmental policy deployment, and financial development: Fresh evidence from India. *Resources Policy*, 90, 104681. <https://doi.org/10.1016/j.resourpol.2024.104681>
- Mohsin, M., Ullah, H., Iqbal, N., Iqbal, W., & Taghizadeh-Hesary, F. (2021). How external debt led to economic growth in South Asia: A policy perspective analysis from quantile regression. *Economic Analysis and Policy*, 72, 423 – 437. <https://doi.org/10.1016/j.eap.2021.09.012>
- National Statistical Office. (2025). *First revised estimates of national income, consumption expenditure, saving and capital formation, 2024 – 25*. Ministry of Statistics and Programme Implementation, Government of India. <https://mospi.gov.in/>
- Nenavath, S., & Mishra, S. (2023). Impact of green finance and fintech on sustainable economic growth: Empirical evidence from India. *Heliyon*, 9 (5), e16301. <https://doi.org/10.1016/j.heliyon.2023.e16301>
- Pattillo, C., Poirson, H., & Ricci, L. A. (2002). *External debt and growth*. IMF Working Paper No. 02/69.
- Pesaran, M. H., & Shin, Y. (1995). *An autoregressive distributed lag modelling approach to cointegration analysis* (Vol. 9514, pp. 371-413). Cambridge, UK: Department of Applied Economics, University of Cambridge.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16 (3), 289 – 326.
- Ponceno, A. V., & Indumati, D. S. (n.d.). *Impact of External Debt on Economic Growth in India: An Econometric Analysis*.
- Qamruzzaman, Md., & Jianguo, W. (2018). Nexus between financial innovation and economic growth in South Asia: Evidence from ARDL and nonlinear ARDL approaches. *Financial Innovation*, 4 (1), 20. <https://doi.org/10.1186/s40854-018-0103-3>
- Qayyum, A., Arslan, A., Malik, A. H., Khan, S. N., Rehman, A. U., Asim, M., Ahmad, S., & ElAffendi, M. A. (2025). Financial innovation can hamper the sustainable economic growth: A tale of two emerging economies. *Journal of Open Innovation: Technology, Market, and Complexity*, 11 (1), 100446. <https://doi.org/10.1016/j.joitmc.2024.100446>
- Reserve Bank of India. (2025). *Annual report 2024 – 25*. Reserve Bank of India.
- Reserve Bank of India. (2025). *India’s external debt: A status report, end-December 2024*. Reserve Bank of India.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98 (5), S71 – S102. <https://doi.org/10.1086/261725>

- Rooj, D., & Kaushik, P. D. (2024). Innovation and economic growth in India: An empirical analysis. *Journal of Innovation and Entrepreneurship*. (Update the volume, issue, and page numbers if available.)
- Roy, A. (2023). Nexus between economic growth, external debt, oil price, and remittances in India: New insight from novel DARDL simulations. *Resources Policy*, 83, 103742. <https://doi.org/10.1016/j.resourpol.2023.103742>
- Samal A (2018) An empirical analysis of asymmetry and threshold effect of intergovernmental grants in India: a panel data analysis. *Glob Bus Rev*. Retrieved from <http://journals.sagepub.com/doi/abs/10.1177/0972150918761083>
- Singh, B. P., & Kumar, S. (2024). Public Debt and Economic Growth in India: The New Evidence. *Millennial Asia*, 15 (3), 429 – 446. <https://doi.org/10.1177/09763996221136908>
- Strøm, S. (1999). Econometrics and economic theory in the 20th century: The Ragnar Frisch Centennial Symposium.
- World Bank. (2024). *Global economic prospects* (June 2024). World Bank. <https://doi.org/10.1596/978-1-4648-2050-3>
- World Bank. (2025). *India development update: Expanding opportunities for growth*. World Bank.
- World Bank. (2024). *International debt report 2024*. World Bank. <https://doi.org/10.1596/978-1-4648-2145-6>
- United Nations Conference on Trade and Development. (2024). *World investment report 2024: Investment facilitation and digital government*. United Nations. <https://unctad.org/publication/world-investment-report-2024>