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India's Finance-Growth Nexus with Carbon Emissions, Globalization, and Government Expenditure: A Non-Linear Approach Using ARDL and VARX Techniques

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ABSTRACT: This study examines the causal relationship between financial development and economic growth (i.e., the finance-growth nexus) in India from 1970 to 2020. It is motivated as understanding the relationship between financial development and economic growth is crucial for policy formulation, particularly in emerging economies like India. Assuming the potential non-linearity of India's finance-growth nexus, we employ Autoregressive Distributed Lag (ARDL) and Vector Autoregression with Exogenous Variables (VARX) cointegration techniques. It is also investigated how key control variables—carbon emissions, globalization, and government expenditure—affect this nexus. Economic growth is measured by real per capita GDP, while financial development is proxied by two indicators: financial depth (the ratio of private credit to GDP) and financial efficiency (the ratio of private credit to total deposits), which is one invention of this study. Using both ARDL and VARX techniques, our findings reveal a bidirectional and non-linear relationship between financial development and economic growth, irrespective of the financial development proxy used. This bidirectional relationship highlights the intertwined nature of economic growth and financial development, suggesting that policies targeting either must consider the implications for the other, particularly within the current context of sustainable development and globalization.

KEYWORDS: Economic Growth, Financial Development, Cointegration, ARDL, VECM, India

I. INTRODUCTION

The finance-growth nexus, which analyses the intricate relationship and mutual interactions between financial development and economic growth, is a crucial area of study. Robust financial systems are widely recognized as essential for fostering economic growth. Indeed, nations with well-developed financial sectors consistently exhibit significantly higher and more stable economic growth, demonstrating a strong positive correlation between financial deepening and GDP per capita across diverse economies. This highlights financial development's crucial role in driving economic advancement by facilitating key functions such as credit provision, risk management, and efficient resource allocation (World Bank, 2020).

In developing countries, financial institutions, particularly commercial banks, play a pivotal role in fostering economic expansion by providing essential services such as credit, insurance, and payment systems (Dombi and Grigoriadis, 2020). These services are crucial for stimulating investment, managing risk, and efficiently allocating resources. This significance is underscored by the dramatic expansion of global financial assets, which soared from approximately $440 trillion (13.2 times global GDP) in 2000 to $1,540 trillion in 2020 (McKinsey Global Institute, 2021). However, the precise mechanisms through which finance contributes to growth remain a research question. While a substantial body of literature exists, the specific conditionalities of this relationship, particularly within the context of rapidly evolving economies, are not fully understood. This research gap motivates us to delve deeper into the finance-growth nexus in a specific and significant emerging economy.

The present study investigates the finance-growth nexus in India, a rapidly growing economy with more than 1.4 billion population and complex financial landscape. We believe that India provides a unique backdrop for examining the finance-growth nexus. India's economic landscape underwent a dramatic transformation following the liberalization reforms of 1991 (see Narasimham Committee Reports, 1998; 1991). This period witnessed a significant shift in the country's financial sector, with a focus on deregulation, privatization, and globalization (see Jalan, 2000; Nayyar, 2017). However, while the relationship between finance and economic growth has been widely debated by academics and policymakers, it remains surprisingly underexplored.

The relationship between financial development and economic growth in India has been a subject of ongoing scholarly debate. This study aims to contribute to this discussion by employing rigorous econometric techniques to annual data spanning 1970-2020, specifically utilizing autoregressive distributed lag (ARDL) and vector autoregression with exogenous variables (VARX) cointegration to model the potentially nonlinear dynamics. Recognizing that a singular focus on the finance-growth nexus may lead to model misspecification, as highlighted by prior research (Luintel and Khan, 1999; Cevik and Rahmati, 2020), this research expands the analytical framework to incorporate three crucial and interconnected factors: carbon emissions, globalization, and government expenditure. The inclusion of carbon emissions is paramount in the context of sustainable development and the global pursuit of Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) (United Nations, 2025). Financial development can both enable investments in green technologies and potentially fuel carbon-intensive activities through increased economic activity. Globalization, while a significant driver of economic growth (Sanusi and Dickason-Koekemoer, 2024; Anwar and Iwasaki 2023), creates complex linkages with both finance and the environment. Increased trade (exports and imports) facilitated by globalization can accelerate financial development but may also lead to higher carbon emissions through expanded production and consumption. Government expenditure can act as a traditional policy lever, influencing economic growth (through a range of growth policies), financial development (e.g., through infrastructure investment) and environmental outcomes (e.g., through green subsidies or carbon taxes).

This paper contributes to the literature by examining how India's finance-growth nexus is influenced by the forces of carbon emissions, globalization, and government expenditure. By analysing the direct and indirect linkages between these variables, and accounting for structural breaks in India's economic growth, this study aims to provide a more policy-relevant understanding of the finance-growth nexus in an era defined by environmental concerns and increasing global interconnectedness. The application of advanced time-series econometrics (ARDL and VARX) enables us to capture these complex relationships and provide robust empirical evidence to inform policymakers addressing sustainable economic development in India.

The remainder of this paper is organized as follows. Section 2 presents a review of the existing literature on the finance-growth nexus, highlighting the key theoretical perspectives and empirical findings. Section 3 discusses the data and methodology used in the analysis. Section 4 presents the empirical results, including the estimated causal relationships between economic growth and financial development, as well as the impact of third variables. Finally, Section 5 concludes the paper by summarizing the key findings and discussing policy implications.

II. LITERATURE REVIEW

The finance-growth nexus has been a subject of intense scholarly debate for decades. A vast body of literature has emerged, offering diverse theoretical perspectives and empirical evidence. Schumpeter (1934) provided foundational insights, arguing that well-developed financial systems stimulate economic growth by fostering innovation, entrepreneurship, and productivity gains. This perspective highlights the role of finance in channelling resources to productive investments. McKinnon (1973) and Shaw (1973) further refined this understanding, emphasizing the positive impact of interest rates, the role of financial intermediaries, and the importance of market-based allocation. These insights are often encapsulated in the concept of moving from 'financial repression' to 'financial liberalization. On the other hand, there are alternative perspectives that challenge the straightforward positive impact of financial development on economic growth. Robinson (1952) argued that economic growth itself generates demand for financial services, leading the financial system to adapt accordingly. This suggests a causal relationship running from growth to finance rather than the other way around. Lucas (1988) provided a more nuanced view, suggesting that excessive financial intermediation can sometimes impede growth by misallocating resources and increasing systemic risk.

Patrick (1969) summarized these arguments, which can be categorized into mainly three primary perspectives. First, the supply-leading hypothesis posits that financial development precedes and drives economic growth. Well-developed financial systems, by providing essential services like credit, insurance, and payment systems, can stimulate investment, innovation, and entrepreneurship, ultimately leading to economic expansion. Second, the demand-following hypothesis argues that economic growth drives financial development. As economies grow, the demand for financial services increases, leading to the expansion of financial institutions and the development of financial markets. Third, the bilateral causality hypothesis suggests a mutually reinforcing relationship between financial development and economic growth. Financial development can stimulate growth, while economic growth can create conditions conducive to further financial development.

To reconcile the debate surrounding the finance-growth nexus, numerous empirical studies have been conducted for developing countries. These studies employ diverse econometric methodologies and control variables across various sample periods. However, their findings remain inconclusive, often yielding contradictory results (Marwa and Zhanje, 2015). These range from a unidirectional causality, where finance drives growth or vice versa, to a bidirectional relationship or even a nonlinear association[1]. Recent empirical evidence increasingly suggests a more nuanced, nonlinear relationship (Udoh et al., 2021; Sohag et al., 2019). Specifically, while financial development appears to promote economic growth up to a certain threshold, facilitating investment, innovation, and efficient resource allocation, beyond this threshold its effect may become negative. This negative impact can arise through various channels, such as excessive credit expansion leading to financial instability and crises, or the misallocation of capital towards speculative activities rather than productive investments (Ahmed et al., 2022).

Empirical studies on India's finance-growth nexus also present a mixed picture. Several studies suggest a positive influence of financial development on economic growth. For example, Kumar and Paramanik (2020), using a non-linear autoregressive distributed lag (NARDL) bound test, demonstrated a long-run positive impact. Similarly, Chowdhury et al. (2021) employed the Johansen cointegration technique and found unilateral causality running from finance to economic growth. However, other studies point to a more complex, bidirectional relationship. Latif et al. (2018) and Wu et al. (2020) found evidence of bidirectional positive causality between financial development and economic growth. Nayak (2020) also identified a bidirectional causal flow between these two variables in the long run. Further adding to the complexity, Fukuda (2020), used two different finance indices and found different relationships between financial development and economic growth, depending on the index used.

III. EMPIRICAL STRATEGY AND DATA

To empirically examine India's finance-growth nexus, we propose the following basic models:

$$EG_t = f_1(FS_t, FSSQ_t, COTWO_t, GL_t, GE_t) \ (1)$$
$$FS_t = f_2(EG_t, EGSQ_t, COTWO_t, GL_t, GE_t) \ (2)$$
$$EG_t = f_3(FE_t, FESQ_t, COTWO, GL_t, GE_t) \ (3)$$
$$FE_t = f_4(EG_t, EGSQ_t, COTWO_t, GL_t, GE_t) \ (4)$$

Equations 1, 2, 3, and 4 are exhibited to conduct Granger causality tests, investigating the causal relationships between economic growth (EG, measured by real per capita GDP) and two financial development indicators: financial size (FS, represented by the ratio of private credit to GDP) and financial efficiency (FE, measured by the ratio of private credit to total deposits) (Beck et al., 2010). To account for potential nonlinear effects in the cointegration analysis, we include squared terms of EG, FS, and FE (EGSQ, FSSQ, and FESQ, respectively) in each equation. To address potential omitted variable bias, we incorporate the third variables of carbon emissions (COTWO), globalization (GL), and government expenditure (GE) into the models. These factors are relevant given India's commitments to sustainable development goals, increasing extent of globalization, and the importance of fiscal policy in achieving economic objectives.

By estimating Equations 1 and 2, we aim to determine the direction of causality between economic growth and financial size (i.e., whether FS Granger-causes EG, EG Granger-causes FS, or a bidirectional relationship exists). Similarly, Equations 3 and 4 are used to assess the causal relationship between economic growth and financial efficiency (i.e., whether FE Granger-causes EG, EG Granger-causes FE, or a bidirectional relationship exists).

Data for the variables were sourced from various reliable sources. Carbon emissions per capita data were obtained from Our World in Data (2025). Globalization was measured using the KOF globalization index provided by the KOF Swiss Economic Institute (2025). This index measures the degree of globalization covering 122 countries and using 24 variables across the economic, social, and political dimensions of globalization. Economic growth, the two financial development indicators, and government expenditure were retrieved from the World Bank's World Development Indicators (WDI) (World Bank, 2025). The sample period of 1970-2020 was selected primarily due to the availability of the KOF globalization index, and it encompasses the initial period of the COVID-19 pandemic, enabling us to explore its potential impact on India's finance-growth nexus.

IV. METHODOLOGY

To investigate India's finance-growth nexus, we employ both Autoregressive Distributed Lag (ARDL)[2] and Vector Autoregression with Exogenous Variables (VARX) methodologies. Recognizing the importance of dynamic adjustments in economic time series, as

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[1] There is another argument on the finance-growth nexus. Cross-country studies suggest financial development boosts economic growth (e.g., King and Levine, 1993). However, some argue these studies assume similar growth patterns across countries, ignoring country-specific factors (e.g., Demetriades and Hussein, 1996). This raises the question: if countries pursue diverse development strategies, why do they share the same finance-growth relationship?

[2] To explore potential nonlinearities in estimation, we considered the Nonlinear Autoregressive Distributed Lag (NARDL) model, developed by Shin et al. (2014). NARDL extends the ARDL framework by allowing for the decomposition of the independent variables into their positive and negative partial sums, to capture asymmetric effects in both the short and long run. However, we use the regular ARDL model for two reasons. First, we wanted to confirm if there's a basic, long-term connection between the

emphasized by Engle and Granger (1987), we incorporate error correction models (ECMs) into both frameworks to examine long-run equilibrium relationships. By employing these rigorous econometric techniques, we aim to provide robust empirical evidence on the causal relationship between financial development and economic growth, considering the influence of control variables. The following subsections detail the unit root tests and the methodologies of these two procedures.

A. Unit Root Tests

To initiate the cointegration analysis, we need to determine the integration order of each underlying variable using unit root tests. The ARDL and VARX approaches to cointegration impose specific requirements on the order of integration of the variables. ARDL models necessitate that all variables be either I(0) or I(1), while VARX models demand that all variables be I(1). To meet these criteria, we employ two robust unit root tests: the GLS-ADF test (Elliott et al., 1996) and the PP test (Phillips and Perron, 1988). The GLS-ADF test, a modified version of the standard ADF test, utilizes Generalized Least Squares (GLS) to mitigate the impact of autocorrelation in the residuals. The PP test is also designed to be robust to serial correlation.

B. ARDL Procedure

The present study's ARDL procedure is explained with the following equations consisting of six underlying variables:

$$\Delta EG_t = \alpha_{it}\begin{bmatrix} EG_t \\ FS_t \\ FSSQ_t \\ COTWO_t \\ GL_t \\ GE_t \end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta FS_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta FSSQ_{t-j} \quad + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \ (5)$$

$$\Delta FS_t = \alpha_{it}\begin{bmatrix} FS_t \\ EG_t \\ EGSQ_t \\ COTWO_t \\ GL_t \\ GE_t \end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta FS_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta EGSQ_{t-j} \quad + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \ (6)$$

$$\Delta EG_t = \alpha_{it}\begin{bmatrix} EG_t \\ FE_t \\ FESQ_t \\ COTWO_t \\ GL_t \\ GE_t \end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta FE_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta FESQ_{t-j} \quad + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \ (7)$$

$$\Delta FE_t = \alpha_{it}\begin{bmatrix} FE_t \\ EG_t \\ EGSQ_t \\ COTWO_t \\ GL_t \\ GE_t \end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta FE_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta EGSQ_{t-j} \quad + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \ (8)$$

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underlying variables. Second, the regular ARDL model gives us a simple starting point to understand the general effect of these factors on the finance-growth nexus.

The ARDL estimation starts with the bounds test, which is based on F-statistics, is performed to check the existence of a long-run cointegrating relationships between the underlying variables, irrespective of whether those variables are I(0) or I(1) (Pesaran et al., 2001). In Equations (5) and (6), EG and FS are the dependent variables, respectively, while in Equations (7) and (8), EG and FE are the dependent variables. If the calculated F-statistics exceeded the upper bound critical value, the null hypothesis of no cointegration is rejected. However, if the F-statistics fall within the lower and upper bound critical values, the test is inconclusive, and unit root tests are consulted. Subsequently, the optimal lag order for each variable is determined using either the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC).

To interpret the ARDL estimation, two types of Granger causality tests are conducted. Weak exogeneity tests the null hypothesis that the coefficient on the lagged error correction term (ECT) is zero (H0: αit = 0). Rejecting this null hypothesis indicates a significant ECT, implying a long-run causal relationship between the variables. Strong exogeneity tests the joint null hypothesis that the ECT coefficient and all coefficients on the lagged independent variables are zero (H0: αit = θij's = 0). Rejecting this null hypothesis suggests significant overall (long-run and short-run) causality within the ARDL system, regardless of time spans (Charemza and Deadman, 1997).

C. VARX Procedure

The VARX model is a powerful tool in time series analysis, well-suited for examining cointegration relationships between multiple time series variables (Pesaran et al., 2000). A key advantage of the VARX model is its ability to demonstrate a clear direction of influence through the signs of the coefficients of each underlying variable in the cointegrating space. Uniquely, the VARX model can treat certain variables as I(1) exogenous variables, incorporating them into the cointegrating space without considering them as endogenous. As outlined in Section 4.1, the VARX assessment begins with unit root tests to determine the stationarity or integration order of the underlying variables; all variables must be I(1) to proceed. The next step is to conduct the Johansen (1988) cointegration test, which identifies the presence of long-run relationships among the variables. In this context, we seek evidence of a single cointegrating relationship (r = 1).

Given the need for an error correction representation in VARX models with cointegrated variables, we propose the following equations:

$$\begin{bmatrix}\Delta EG_t\\ \Delta FS_t\end{bmatrix} = \alpha_{it}\begin{bmatrix}EG_t\\ FS_t\\ FESQ_t\\ COTWO_t\\ GL_t\\ GE_t\end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta FS_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta FSSQ_{t-j} + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \quad (9)$$

$$\begin{bmatrix}\Delta FS_t\\ \Delta EG_t\end{bmatrix} = \alpha_{it}\begin{bmatrix}FS_t\\ EG_t\\ EGSQ_t\\ COTWO_t\\ GL_t\\ GE_t\end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta FS_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta EGSQ_{t-j} + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \quad (10)$$

$$\begin{bmatrix}\Delta EG_t\\ \Delta FE_t\end{bmatrix} = \alpha_{it}\begin{bmatrix}EG_t\\ FE_t\\ FESQ_t\\ COTWO_t\\ GL_t\\ GE_t\end{bmatrix} + \sum_{j=1}^{p-1}\theta_{1j}\,\Delta EG_{t-j} + \sum_{j=1}^{p-1}\theta_{2j}\,\Delta FE_{t-j} + \sum_{j=1}^{p-1}\theta_{3j}\,\Delta FESQ_{t-j} + \sum_{j=1}^{p-1}\theta_{4j}\,\Delta COTWO_{t-j} + \sum_{j=1}^{p-1}\theta_{5j}\,\Delta GL_{t-j} + \sum_{j=1}^{p-1}\theta_{6j}\,\Delta GE_{t-j} + inpt + u_{it} \quad (11)$$

$$\begin{bmatrix} \Delta FE_t \\ \Delta EG_t \end{bmatrix} = \alpha_{it} \begin{bmatrix} FE_t \\ EG_t \\ EGSQ_t \\ COTWO_t \\ GL_t \\ GE_t \end{bmatrix} + \sum_{j=1}^{p-1} \theta_{1j}\, \Delta FE_{t-j} + \sum_{j=1}^{p-1} \theta_{2j}\, \Delta EG_{t-j} + \sum_{j=1}^{p-1} \theta_{3j}\, \Delta EGSQ_{t-j} + \sum_{j=1}^{p-1} \theta_{4j}\, \Delta COTWO_{t-j} + \sum_{j=1}^{p-1} \theta_{5j}\, \Delta GL_{t-j} + \sum_{j=1}^{p-1} \theta_{6j}\, \Delta GE_{t-j} + inpt + u_{it} \quad (12)$$

where the first terms of the estimated VARX model (Equations 9-12) are 2 × 1 vectors of the dependent variables; the second terms are the cointegrating vectors, which capture the long-run equilibrium relationship between the endogenous variables (EG and either FS or FE) and I(1) exogenous variables (EGSQ/FSSQ/FESQ, COTWO, GL, GE), respectively. The error correction term (ECT), whose coefficient is αit, measures the deviation from the long-run equilibrium and drives the system back to its equilibrium state. The lag order p is chosen for the system, and uit is the error term. Finally, similar to the ARDL procedure, both weak exogeneity test (H0: αit = 0) and strong exogeneity tests (H0: αit = θij's = 0) are implemented to interpret the VARX estimation results.

D. Structural Break Dummy

To enhance the robustness of our cointegration analysis, we incorporate a level shift dummy variable in both the ARDL and VARX estimations, following Johansen et al. (2000). This approach is particularly relevant in the context of India's economic growth, where structural breaks can significantly influence the finance-growth nexus. To identify optimal break dates in the real GDP series, we employ the Lee-Strazicich (2003; 2004) (LS) and Zivot-Andrew (1992) (ZA) tests, both of which utilize autoregression to determine break date(s). Including these break dates in the structural break dummy allows us to assess the impact of structural changes on the cointegration relationship. This approach not only improves the accuracy of our analysis but also enables us to seek a single cointegration vector (r = 1) and eliminate autocorrelation (Fukuda, 2024).

The LS test is calculated for Models A and AA, which introduce one and two breaks in level without altering the trend rate, respectively. Level shift dummy variables are constructed based on the LS breakpoints identified in India's EG series from 1970 to 2020. These dummies are SBONELS (Structural Break, ONE, LN test) model with a break date of 1978 and SBTWOLS (Structural Break, TWO, LN test) model with break dates of 1990 and 2001. Likewise, the Zivot-Andrews (ZA) test, which autoregressively identifies a single level break date, is used to create a level shift dummy variable for SBONEZA (Structural Break, ONE, ZA test) model with a break date of 1979.

V. EMPIRICAL RESULTS

We begin this section by presenting unit root test results, followed by a thorough discussion of ARDL and VARX findings for India's finance-growth nexus.

A. Unit Root Tests' Results

To confirm the stationarity of each variable, we conducted both the Augmented Dickey-Fuller Generalized Least Squares (ADF-GLS) and Phillips-Perron (PP) tests, considering two specifications: "with an intercept only" and "with both an intercept and a trend". As shown in Table 1, all the underlying variables (EG, EGSQ, FS, FSSQ, FE, FESQ, COTWO, GL, and GE) are non-stationary in levels but become stationary after first differencing, as indicated by significance levels of 1% and 5%. Consequently, we judge that all underlying variables are integrated of order one, or I(1), making them suitable for both ARDL) and VARX modelling.

Table 1. ADF-GLS and PP Test Results (*k* = 1)

	ADF-GLS Test		PP Test	
	Inpt. only	Inpt.. & Trend	Inpt. only	Inpt. & Trend
EG	0.747	-1.211	2.031	-2.775
ΔEG	-2.351**	-3.482**	-5.124***	-5.640***
EGSQ	0.431	-1.217	2.371	-2.403
ΔEGSQ	-2.351**	-3.482**	-5.124***	-5.640***
FS	0.894	-1.500	-1.624	-1.827
ΔFS	-2.525**	-3.399**	-6.005***	-5.987***

FSSQ	1.014	-1.525	-0.992	-1.532
ΔFSSQ	-2.741**	-3.237**	-5.976***	-5.900***
FE	0.0246	-1.162	-1.040	-1.207
ΔFE	-1.762	-2.787	-7.623***	-7.682***
FESQ	0.671	-0.858	0.284	-0.253
ΔFESQ	-2.677**	-3.385**	-6.473***	-6.710***
COTWO	0.089	-2.052	-0.508	-1.962
ΔCOTWO	-2.455**	-2.511	-4.539***	-4.397***
GL	-0.060	-1.551	-0.257	-1.286
ΔGL	-3.413***	-3.442**	-3.849***	-3.808**
GE	-1.286	-2.562	-2.292	-2.475
ΔGE	-3.459***	-5.084***	-5.847***	-5.751***

Notes: (***) 1% and (**) 5% level of significance. The critical values are simulated with 1000 replications.
Source: Author

B. ARDL Results

To confirm the stationarity of each variable, we conducted both the Augmented Dickey-Fuller Generalized Least Squares (ADF-GLS) and Phillips-Perron (PP) tests, considering two specifications: "with an intercept only" and "with both an intercept and a trend".

1) Bound Test and Diagnostic Test Results

Tables 2-5 present the ARDL results of India's finance-growth nexus (see Panel A of each table for the following discussion). Models I-A and I-B utilize Financial Size (FS) as the financial development indicator, while Models II-A and II-B employ Financial Efficiency (FE). The maximum lag order is set to 4 for Models I-A, II-A, and II-B, and 2 for Model I-B. The lag order for each underlying variable is selected using either the Akaike information criterion (AIC) (for Models I-A and II-B) or the Schwarz Bayesian criterion (SBC) (for Models I-B and II-A). Notably, these models incorporate different structural break dummies (either SBONELS or SBTWOLS). Empirical analysis reveals that all four models exhibit ARDL cointegration at the 5% significance level (see "Bounds Test Statistics"). With lag sections and structural break dummies, our four models effectively capture long-run relationships without significant diagnostic issues (autocorrelation, functional form, normality, and heteroskedasticity). Furthermore, the models achieve acceptable goodness-of-fit (R^2), explaining between 56% and 69% of the variance in the dependent variable. These results strongly support the suitability of the ARDL framework for analysing India's finance-growth nexus.

2) ARDL Economic Growth and Financial Size

We first look at the ARDL results using financial size as the financial development indicator (see Panel B of Tables 2 and 3 for the following discussion). The weak exogeneity tests demonstrate statistically significant negative ECT coefficients (α) at the 5% level or better for both Models I-A and I-B, thus confirming the existence of a long-run error-correcting relationship[3]. Next, we determine the direction of causality within India's finance-growth nexus by checking the signs of the underlying variables in the cointegrating vector, in conjunction with strong exogeneity test results. Considering the impact of financial size (FS) on economic growth (EG) (Panel B of Table 2), we find a statistically significant ($p < 0.01$) inverted U-shaped relationship. Financial size has a positive effect on economic growth, while its squared term (FSSQ) has a negative effect.

Equally, examining the effect of economic growth on financial size (Panel B of Table 3) reveals a U-shaped relationship ($p < 0.01$): economic growth (EG) has a negative effect on financial size (FS), and its squared term (EGSQ) has a positive effect. Using the ARDL procedure, we conclude India's finance-growth nexus is bilateral and non-linear with respect to financial size.

3) ARDL Economic Growth and Financial Efficiency

Next, we report the ARDL results using financial efficiency (FE) as the financial development indicator (see Panel B of Tables 4 and 5 for the following discussion). Weak exogeneity tests detect negative and statistically significant ECTs (at the 5% level or better) in both Models II-A and I-B, confirming the existence of a long-run relationship. To determine the direction of causality, we examine the signs of the variables within the cointegrating vector and conducted strong exogeneity tests to test for overall (long-run and short-run) causality. Our analysis reveals a statistically significant ($p < 0.01$) U-shaped relationship between financial

[3] The ECTs for all eight ARDL and VARX models in this study fall between -1 and -2. This range is considered statistically sound, suggesting appropriate model convergence (Banerjee et al., 1998).

efficiency and economic growth (Panel B of Table 4). This suggests that financial efficiency (FE) initially exerts a non-positive effect on economic growth (EG), transitioning to a pro-growth effect at later stages of development.

On the other hand, the effect of economic growth on financial efficiency (Panel B of Table 5) indicates a positive and accelerating relationship, with both economic growth (EG) and its squared term (EGSQ) positively contributing to increased financial efficiency (FE). With respect to financial efficiency, the ARDL analysis finds out a bilateral and non-linear relationship between finance and growth in India. These findings present a complex and unexpected pattern.

4) ARDL Effects of Third Variables

Within the ARDL framework, we also consider the effects of carbon emissions, globalization, and government expenditure on economic growth, financial size, and financial efficiency. The findings reveal a statistically significant positive relationship between carbon emissions (COTWO) and economic growth (EG) ($p < 0.01$), a result consistent across various indicators of financial development. While the impact of carbon emissions on financial size (FS) is marginally significant and positive ($p < 0.10$), its effect on financial efficiency (FE) is significantly negative ($p < 0.01$), suggesting a complex relationship. Globalization (GL) demonstrates a robust positive influence on economic growth, financial size, and financial efficiency ($p < 0.01$) across all model specifications. Conversely, government expenditure (GE) shows a negative relationship with economic growth, irrespective of the financial indicator used ($p < 0.01$). However, it positively impacts both financial size and financial efficiency ($p < 0.01$).

Table 2. ARDL Results (Model I-A)

Panel A		
Dependent Variable	Endogenous Variables	Deterministic Components
EG	FS, FSSQ, COTWO, GE, GL	SBONELS(rest.), Intercept(rest.)
Maximum Lag, Criteria	Selected Lag orders	Bounds Test Statistic
k= 4, AIC	(1,3,3,0,4,0)	11.26**
Autocorrelation	Functional Form	Goodness-of-Fit Tests
2.778 [.107]	2.504 [.125]	R: 0.791
Normality	Heteroscedasticity	R2: 0.669
1.307 [.520]	1.087 [.303]	
Panel B		
Weak Exogeneity Test		
α = -0.242	CHSQR(1) = 16.88[.000]***	
Cointegrating Vector		
$EG = 7.065FS - 1.093FSSQ + 0.996COTWO + 0.652GL - 0.455GE - 0.436SBONELS - 5.437$		
Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔFSs & ECT(-1)	CHSQR(4) = 58.22 [.000]***	Positive
ΔFSSQ & ECT(-1)	CHSQR(2) = 58.63 [.000]***	Negative

ΔCOTWO & ECT(-1)	CHSQR(2) = 17.13 [.000]***	Positive
ΔGLs & ECT(-1)	CHSQR(5) = 39.67 [.000]***	Positive
ΔGE & ECT(-1)	CHSQR(2) = 21.20 [.000]***	Negative

Notes: (***) 1% and (**) 5% of significance. The selected lag orders are (EG, FS, FSSQ, COTWO, GL, GE). Serial correlation, functional form, and heteroscedasticity were tested using F-statistics. Normality was assessed with LM statistics. P-values are provided in parentheses.

Source: Author

Table 3. ARDL Results (Model I-B)

Panel A		
Dependent Variable	Endogenous Variables	Deterministic Components
FS	EG, EGSQ, COTWO, GE, GL	SBTWOLS (rest.), Intercept (rest.)
Maximum Lag, Criteria	Selected Lag orders	Bounds Test Statistic
2, SBC	(2,1,2,0,0,0)	6.465**
Autocorrelation	Functional Form	Goodness-of-Fit Tests
1.526 [.225]	0.434 [.514]	R: 0.661
Normality	Heteroscedasticity	R^2: 0.561
4.007 [.135]	1.423 [.239]	

Panel B

Weak Exogeneity Test

α = -0.088**	CHSQR(1) = 5.152 [.023]**

Cointegrating Vector

$$FS = -27.15EG + 1.944EGSQ + 0.879COTWO + 4.035GL + 3.777GE - 0.256SBTWOLS + 74.18$$

Strong Exogeneity Test

Regressors	Result	Causal Direction
ΔEG & ECT(-1)	CHSQR(2) = 9.398 [.009]***	Negative
ΔEGSQs & ECT(-1)	CHSQR(3) = 24.28 [.000]***	Positive
ΔCOTWO & ECT(-1)	CHSQR(2) = 5.210 [.074]*	Positive
ΔGL & ECT(-1)	CHSQR(2) = 19.96 [.000]***	Positive
ΔGE & ECT(-1)	CHSQR(2) = 11.65 [.003]***	Positive

Notes: (***) 1% and (**) 5% of significance. The selected lag orders are (EG, FS, FSSQ, COTWO, GL, GE). Serial correlation, functional form, and heteroscedasticity were tested using F-statistics. Normality was assessed with LM statistics. P-values are provided in parentheses.

Source: Author

Table 4. ARDL Results (Model II-A)

Panel A		
Dependent Variable	Endogenous Variables	Deterministic Components
EG	FE, FESQ, COTWO, GE, GL	SBONELS (rest.), Intercept (rest.)
Maximum lag, Criteria	Selected Lag orders	Bounds Test Statistic
K = 4, SBC	(3,2,4,0,0,3)	10.41**
Autocorrelation	Functional Form	Goodness-of-Fit Tests
0.563 [.460]	0.616 [.439]	R: 0.812
Normality	Heteroscedasticity	R^2: 0.691
3.413 [.181]	1.340 [.253]	
Panel B		
Weak Exogeneity Test		
α = -0.297***	CHSQR(1) = 17.43 [.000]***	
Cointegrating Vector		

$$EG = -0.635FE + 1.931FESQ + 0.750COTWO + 0.530GL - 1.320GE + 0.065SBONELS + 7.656$$

Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔFEs & ECT(-1)	CHSQR(3) = 23.05 [.000]***	Negative
ΔFESQs & ECT(-1)	CHSQR(5) = 62.19 [.000]***	Positive
ΔCOTWO & ECT(-1)	CHSQR(2) = 17.87 [.000]***	Positive
ΔGLs & ECT(-1)	CHSQR(2) = 25.95 [.000]***	Positive
ΔGEs & ECT(-1)	CHSQR(4) = 43.96 [.000]***	Negative

Notes: (***) 1% and (**) 5% of significance. The selected lag orders are (EG, FS, FSSQ, COTWO, GL, GE). Serial correlation, functional form, and heteroscedasticity were tested using F-statistics. Normality was assessed with LM statistics. P-values are provided in parentheses.

Source: Author

Table 5. ARDL Results (Model II-B)

Panel A		
Dependent Variable	Endogenous Variables	Deterministic Components
FE	EG, EGSQ, COTWO, GE, GL	SBTWOLS, Intercept
Maximum lag, Criteria	Selected Lag orders	Bounds Test Statistic
K = 4, AIC	(4,0,2,2,4,0)	7.344**
Autocorrelation	Functional Form	Goodness-of-Fit Tests
0.209 [.651]	0.123 [.728]	R: 0.734
Normality	Heteroscedasticity	R^2: 0.569
0.919 [.632]	0.159 [.692]	
Panel B		
Weak Exogeneity Test		
α = -0.593**	CHSQR(1) = 34.68 [.000]***	
Cointegrating Vector		
$FE = 0.950EG + 0.056EGSQ - 1.769COTWO + 0.265GL + 0.488GE + 0.310SBONELS - 9.925$		
Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔEG & ECT(-1)	CHSQR(2) = 34.70 [.000]***	Positive
ΔEGSQs & ECT(-1)	CHSQR(3) = 35.35 [.000]***	Positive
ΔCOTWOs & ECT(-1)	CHSQR(3) = 38.34 [.000]***	Negative
ΔGLs & ECT(-1)	CHSQR(5) = 35.78 [.000]***	Positive
ΔGE & ECT(-1)	CHSQR(2) = 34.77 [.000]***	Positive

Notes: (***) 1% and (**) 5% of significance. The selected lag orders are (EG, FS, FSSQ, COTWO, GL, GE). Autocorrelation, functional form, and heteroscedasticity were tested using F-statistics. Normality was assessed with LM statistics. P-values are provided in parentheses.

Source: Author

C. VARX Results

To confirm the stationarity of each variable, we conducted both the Augmented Dickey-Fuller Generalized Least Squares (ADF-GLS) and Phillips-Perron (PP) tests, considering two specifications: "with an intercept only" and "with both an intercept and a trend".

1) Johansen Cointegration Test and Diagnostic Test Results

The VARX procedure begins with the Johansen cointegration test to identify long-run relationships (see Tables 6-9, Panel A for the following discussion). In the VARX framework, the system includes EG, FS, and FE as endogenous variables. Each of these is, in turn, treated as the dependent variable in separate equations. The variables EGSQ, FSSQ, FESQ, COTWO, GL, and GE are considered I(1) exogenous variables that participate in the long-run cointegrating relationship. While recognizing the crucial role of lag order selection in VARX models, we adopt a more empirical approach, selecting lag lengths that satisfy two criteria: the presence of a single cointegrating relationship (at a 10% significance level or better) and the absence of diagnostic issues. The inclusion of structural break dummies further enhances the models' ability to capture long-run dynamics. The resulting Models III-A, III-B, and IV-A demonstrate acceptable goodness-of-fit (R^2 ranging from 0.439 to 0.687), indicating at least moderate explanatory power and supporting the suitability of the VARX framework. However, Model IV-B exhibits a substantially lower R^2 (0.209), which is generally considered unacceptable. Therefore, while we acknowledge Model IV-B, our analysis and inferences regarding India's finance-growth nexus primarily focus on the other three VARX models.

2) VARX Economic Growth and Financial Size

The VARX results, using financial size (FS) as the indicator of financial development (Tables 6 and 7, Panel B), provide strong evidence of a long-run, error-correcting relationship. This is supported by statistically significant negative error correction term (ECT) coefficients (α) ($p < 0.05$) in the weak exogeneity tests for both Models III-A and III-B. To determine the direction of causality, we consider both the signs of the variables within the cointegrating vector and the strong exogeneity test results. Examining the impact of financial size on economic growth (Table 6, Panel B), we observe a statistically significant ($p < 0.01$) inverted U-shaped relationship. Specifically, financial size (FS) positively influences economic growth (EG), while its squared term (FSSQ) exerts a negative influence. Conversely, when examining the effect of economic growth on financial size (Table 7, Panel B), we find a U-shaped relationship ($p < 0.01$): EG negatively affects FS, and its squared term (EGSQ) has a positive effect. These VARX findings corroborate the ARDL ones, confirming a bilateral and non-linear finance-growth nexus in India with respect to financial size.

3) VAXR Economic Growth and Financial Efficiency

Next, we analyse the VARX results using financial efficiency (FE) as the financial development indicator. Weak exogeneity tests yield negative and statistically significant ECTs (α) ($p < 0.01$) in both Models IV-A and IV-B, confirming a long-run relationship. Again, we determine causality by examining the signs of the variables within the cointegrating vector and conducting strong exogeneity tests. The estimation reports a statistically significant ($p < 0.01$) U-shaped relationship between financial efficiency (FE) and economic growth (EG) (Table 8, Panel B). This suggests that financial efficiency appears to have an initially negative, then positive, effect on economic growth as development progresses, consistent with the ARDL findings. The effect of economic growth on financial efficiency also indicates a U-shaped relationship, with a negative effect from EG and a positive effect from its squared term (EGSQ) (see Table 9, Panel B). However, because Model IV-B exhibits a substantially lower R^2 (0.209), explaining only 20.9% of the variance in the dependent variable, we place less emphasis on these specific findings.

4) VARX Effects of Third Variables

The VARX analysis also reveals the impact of third variables (carbon emissions, globalization, and government expenditure) on economic growth, financial size, and financial efficiency. Carbon emissions (COTWO) exhibit a significantly positive relationship with economic growth (EG) ($p < 0.01$), regardless of the financial development indicator used. Carbon emissions are significantly negative for both financial size (FS) and financial efficiency (FE) ($p < 0.01$). The globalization (GL) effect on economic growth is dependent on the financial indicator. While marginally positive ($p < 0.10$) when financial size is used, globalization becomes significantly positive ($p < 0.01$) when financial efficiency is the indicator. Furthermore, globalization has a strongly positive impact on both of the financial indicators ($p < 0.01$). Government expenditure (GE) exhibits no effect on economic growth when financial size is the indicator. However, it is significantly positive for economic growth when financial efficiency is used ($p < 0.01$). Government expenditure is significantly and positively associated with both of the financial indicators ($p < 0.01$). Finally, as previously mentioned, the VARX findings for financial efficiency as a dependent variable should be interpreted cautiously due to the lower R-squared value (0.209) observed in Model IV-B.

Table 6. VARX Results (Model III-A)

Panel A

Dep. & End. Variables	I(1) Exo. Variables	Deterministic Components

EG & FS	FSSQ, COTWO, GE, GL	SBONEZA (rest.), Trend(rest.)
Selected Lag	Null	Cointegration Test Statistic
4	r = 0	111.9***
	r < = 1	38.53
Autocorrelation	Functional Form	Goodness-of-Fit Tests
0.108 [.745]	1.452 [.240]	R: 0.707
Normality	Heteroscedasticity	R^2: 0.439
1.140 [.565]	2.404 [.128]	
Panel B		
Weak Exogeneity Test		
α = -0.161	CHSQR(1) = 7.824 [.005]***	
Cointegrating Vector		

$$EG = 2.414FS - 0.478FSSQ + 2.834COTWO + 0.190GL - 1.069GE - 0.340SBONEZA + 0.178Trend$$

Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔFSs & ECT(-1)	CHSQR(4) = 16.33 [.003]***	Positive
ΔFSSQs & ECT(-1)	CHSQR(5) = 15.59 [.008]***	Negative
ΔCOTWOs & ECT(-1)	CHSQR(5) = 35.96 [.000]***	Positive
ΔGLs & ECT(-1)	CHSQ(5) = 9.771 [.082]*	Positive
ΔGEs & ECT(-1)	CHSQR(5) = 8.480 [.132]	—

Notes: (***) 1% and (*) 10% of significance. The tests of autocorrelation, functional form and heteroscedasticity are based on F-version statistics, whereas that of normality is on LM version statistics. In parentheses, p-values are provided.

Source: Author

Table 7. VARX Results (Model III-B)

Panel A		
Dep. & End. Variables	I(1) Exo. Variables	Deterministic Components
FS & EG	EGSQ, COTWO, GE, GL	SBONEZA(rest.), Trend(rest.)
Selected Lag	Null	Cointegration Test Statistic

3	r = 0	77.32**
	r < = 1	29.67
Autocorrelation	Functional Form	Goodness-of-Fit Tests
0.068 [.798]	3.968 [.056]	R: 0.766
Normality	Heteroscedasticity	R^2: 0.645
1.111 [.574]	0.196 [.660]	
Panel B		
Weak Exogeneity Test		
α = -0.199	CHSQR(1) = 33.28 [.000]***	
Cointegrating Vector		

$$FS = -2.158EG + 0.167EGSQ - 5.889COTWO + 0.523GL + 0.457GE - 0.698SBONEZA + 0.254Trend$$

Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔEGs & ECT(-1)	CHSQR(3) = 34.68 [.000]***	Negative
ΔEGSQs & ECT(-1)	CHSQR(4) = 37.35 [.000]***	Positive
ΔCOTWOs & ECT(-1)	CHSQR(4) = 40.46 [.000]***	Negative
ΔGLs & ECT(-1)	CHSQR(4) = 44.02 [.000]***	Positive
ΔGEs & ECT(-1)	CHSQR(4) = 52.00 [.000]***	Positive

Notes: (***) 1% and (**) 5% of significance. The tests of autocorrelation, functional form and heteroscedasticity are based on F-version statistics, whereas that of normality is on LM version statistics. In parentheses, p-values are provided.

Source: Author

Table 8. VARX Results (Model IV-A)

Panel A		
Dep. & End. Variables	I(1) Exo. Variables	Deterministic Components
EG & FE	FESQ, COTWO, GL, GE	SBONELS(unrest.), Intercept(rest.)
Selected Lag	Null	Cointegration Test Statistic
4	r = 0	96.82**
	r < = 1	34.22

Autocorrelation	Functional Form	Goodness-of-Fit Tests
0.036 [.851]	0.677 [.419]	R: 0.844
Normality	Heteroscedasticity	R^2: 0.687
5.131 [.077]	0.005 [.944]	
Panel B		
Weak Exogeneity Test		
α = -0.211	CHSQR(1) = 35.84 [.000]***	
Cointegrating Vector		
$EG = -1.356FE + 3.474FESQ + 0.722COTWO + 0.683GL - 2.052GE + 8.907$		
Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔFEs & ECT(-1)	CHSQR(4) = 38.14 [.000]]***	Negative
ΔFESQs & ECT(-1)	CHSQR(5) = 51.79 [.000]***	Positive
ΔCOTWOs & ECT(-1)	CHSQR(5) = 56.01 [.000]***	Positive
ΔGLs & ECT(-1)	CHSQR(5) = 39.54 [.000]***	Positive
ΔGEs & ECT(-1)	CHSQR(5) = 44.97 [.000]***	Negative

Notes: (***) 1% and (**) 5% of significance. The tests of autocorrelation, functional form and heteroscedasticity are based on F-version statistics, whereas that of normality is on LM version statistics. In parentheses, p-values are provided.

Source: Author

Table 9. VARX Results (Model IV-B)

Panel A		
Dep. & End. Variables	I(1) Exo. Variables	Deterministic Components
FE & EG	EGSQ, COTWO, GL, GE	SBTWOLS(rest.), Trend(rest.)
Selected Lag	Null	Cointegration Test Statistic
2	r = 0	56.55*
	r < = 1	18.76
Autocorrelation	Functional Form	Goodness-of-Fit Tests
1.098 [.301]	2.011 [.165]	R: 0.374

Normality	Heteroscedasticity	R^2: 0.209
0.016 [.992]	0.018 [.893]	
Panel B		
Weak Exogeneity Test		
α = -0.290	CHSQR(1) = 11.05 [.001]***	
Cointegrating Vector		
$FE = -2.703EG + 0.292EGSQ - 3.229COTWO + 0.362GL + 0.682GE - 0.394SBTWOLS + 0.110Trend$		
Strong Exogeneity Test		
Regressors	Result	Causal Direction
ΔEG & ECT(-1)	CHSQR(2) = 14.92 [.001]***	Negative
ΔEGSQs & ECT(-1)	CHSQR(3) = 15.81 [.001]***	Positive
ΔCOTWOs & ECT(-1)	CHSQR(3) = 11.44 [.010]***	Negative
ΔGLs & ECT(-1)	CHSQR(3) = 12.39 [.006]***	Positive
ΔGEs & ECT(-1)	CHSQR(3) = 13.76 [.003]***	Positive

Notes: (***) 1% and (*) 10% of significance. The tests of autocorrelation, functional form and heteroscedasticity are based on F-version statistics, whereas that of normality is on LM version statistics. In parentheses, p-values are provided.

Source: Author

VI. POLICY IMPLICATIONS AND CONCLUSION

This study investigated the finance-growth nexus in India from 1970 to 2020, employing Autoregressive Distributed Lag (ARDL) and Vector Autoregressive with Exogenous variables (VARX) cointegration techniques. It further considered the influence of key third variables: carbon emissions, globalization, and government expenditure. The findings reveal a nonlinear interplay between finance and growth, yielding significant implications for policymakers.

Our analysis demonstrates a bilateral and nonlinear relationship between financial development and economic growth, irrespective of whether financial development is measured by financial size (private credit to GDP) or financial efficiency (private credit to total deposits). This bidirectional causality suggests that, within the context of sustainable development and globalization, policies aimed at promoting economic growth must consider their impact on the financial sector, and vice versa.

The findings related to financial size exhibit an inverted U-shaped relationship with economic growth. This implies that while an initial increase in financial size stimulates economic growth, exceeding a certain threshold may become detrimental. This is crucial for Indian policymakers, highlighting the need for careful monitoring and regulation of credit expansion to mitigate potential negative consequences for economic stability. The detrimental effects of excessive credit expansion on sustainable economic growth, such as asset bubbles and heightened systemic risk, have long been recognized (Qayyum et al., 2024; Alaabed and Masih, 2016). Policymakers should shift their focus from merely maximizing credit volume to optimizing credit allocation towards productive sectors through careful monitoring and regulation.

On the other hand, the findings related to financial efficiency reveal a U-shaped relationship with economic growth. This suggests that initial improvements in financial efficiency may not immediately translate into significant economic growth. However, as financial efficiency continues to improve, its positive impact on growth becomes more pronounced. This implies that long-term investments in strengthening financial institutions, improving regulatory frameworks, and enhancing market transparency are crucial for realizing the full growth potential of a more efficient financial system (Said and Hammam 2024; Mammadov and

Ahmadov 2021). Long-term strategies should prioritize reforms aimed at reducing transaction costs and improving information flow to strengthen financial institutions, improve regulatory frameworks, and enhance market transparency, ultimately realizing the full growth potential of a more efficient financial system.

Thus, while the chosen variables for financial development (private credit to GDP and private credit to total deposits) effectively capture important aspects of size and efficiency, they may not encompass the full spectrum of financial development. Future research could explore alternative measures to provide a more comprehensive understanding.

Furthermore, the study highlights the interconnectedness of carbon emissions, globalization, and government expenditure with the finance-growth nexus. The significant impact of these variables underscores the need for policymakers to adopt an integrated approach. This approach should consider the environmental implications of financial policies, the role of globalization in shaping financial development, and the effectiveness of government expenditure in promoting both financial development and economic growth. For instance, policies promoting green finance and sustainable investments can help mitigate the negative environmental impact of economic growth while simultaneously fostering financial development (Raihan, 2024). Similarly, policies aimed at enhancing integration into the global economy should be complemented by measures to strengthen the domestic financial system and manage potential risks associated with globalization (Özdemir, 2020).

In conclusion, this study provides compelling evidence of a complex, nonlinear, and bidirectional relationship between financial development and economic growth in India. These findings necessitate a departure from simplistic, linear policy approaches. Policymakers should prioritize optimizing credit allocation, enhancing financial efficiency, and understanding the interplay between finance and other critical macroeconomic and environmental factors. This integrated approach must consider the environmental impact of financial policies, strategically leverage globalization opportunities while mitigating potential risks, and ensure government expenditure effectively supports sustainable financial development and economic growth.

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Later it will be written.

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