History of Growth, Volatility, and Asymmetry: Macroeconomic Drivers in Pakistan's Economy

Saira Habib[i]

Adeela Ghazanfar[ii]

ABSTRACT

This study examines the asymmetric effects of key macroeconomic drivers on economic growth in Pakistan, a developing economy characterized by structural imbalances and persistent volatility. While existing literature largely focuses on linear relationships, this research emphasizes how deviations of nominal variables from their equilibrium levels influence growth differently in positive and negative directions. The primary purpose is to analyse the impact of inflation, real exchange rate, and foreign direct investment (FDI) alongside structural factors such as energy consumption, urbanization, trade openness, capital formation, and carbon emissions on per capita GDP. The study employs annual time series data from 1980 to 2024 and applies the Nonlinear Autoregressive Distributed Lag

i Assistant Professor, COMSTAS University Islamabad. Email: *saira.habib@comsats.edu.pk*

ii Assistant Professor, School of Social Sciences & Humanities, NUST, Islamabad. Email: *adeela@s3h.nust.edu.pk*.

(NARDL) model to capture both short-run and long-run asymmetries. Unit root tests and bounds testing are used to ensure the validity of long-run relationships, while diagnostic tests confirm model stability. The findings reveal significant asymmetric effects: energy consumption, industrial growth, and trade openness positively influence growth, whereas high inflation and exchange rate misalignment adversely affect it. Moreover, positive and negative shocks to key variables have unequal impact, confirming nonlinear dynamics. Environmental factors also present trade-offs between growth and sustainability. The study implies that policymakers should prioritise macroeconomic stability, promote efficient energy use, maintain exchange rate alignment, and design balanced policies to achieve sustainable and inclusive economic growth.

Introduction

In developing economies, such as Pakistan, macroeconomic stability, structural constraints, and policy certainty are key to economic growth. Price level, exchange rate, interest rate, and FDI reputedly play vital roles in the economy. The direct impact of these on growth has been much studied, but not their equilibrium deviations and asymmetries. Deviations generate uncertainties, distort prices, hinder investments, and thwart long-term growth. Nominal variables' stable evolution around equilibrium levels helps to plan economic activities and maintain expectations. In developing nations such as Pakistan, these variables tend to deviate because of external shocks, fiscal deficits, rigid economic structures and speculation. Variance is associated with structural factors like monetary policy, capacity, capital and trade.

Macroeconomic variables are related to GDP, inflation, exchange rate distortions, and excessive money growth harm GDP when these variables are out of equilibrium. Macroeconomic stability is needed for long-term growth. Much empirical research has demonstrated that disequilibrium and instability affect macroeconomic variables. Inflationary and exchange rate variations increase

uncertainty, restrict investments and slow growth.[1] In the short run, volatile and high inflation misdirects capital formation and moves away from equilibrium, having more impact than low inflation.[2] Issues of contract length and 'spikes' of inflation during crises have also been observed as reducing.[3] Such evidence suggests that we need to consider inflation by level, variability and equilibrium.

Exchange rate misalignment is a second critical macroeconomic instability-growth mechanism. Sustained overvaluation (or undervaluation) causes misallocation of resources between tradable and non-tradable activities, destroys export competitiveness, and retards growth.[4] Volatility of exchange rates is particularly detrimental to productivity in countries with poor financial development.[5] Over- and undervalued exchange rates both reduce efficiency. FDI input stability also impacts economic growth. FDI stability enhances productivity by technology transfer, industrial development, and investment. Unanticipated FDI outflow or instability affects the investment cycle, reducing productivity. Retreat of FDI signals external uncertainty, leading to short-term speculative investment rather than structural, long-term investment.

Interest rate fluctuations aggravate macroeconomic exuberance. Sub-optimal rates increase interest, reduce credit, and crowd-out private investment. For countries with

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1 Stanley Fischer, "The Role of Macroeconomic Factors in Growth." *Journal of Monetary Economics* 32, No. 3 (1993): 485–512.

2 Robert J. Barro, 'Inflation and Economic Growth," *Bank of England Quarterly Bulletin* 35, No. 2 (1995):161–177.

3 Michael Bruno and William Easterly, "Inflation Crises and Long-Run Growth," *Journal of Monetary Economics* 41, No. 1 (February 1998): 3–26.

4 Sebastian Edwards, *Real Exchange Rates, Devaluation, and Adjustment: Exchange Rate Policy in* Developing Countries (Cambridge, MA: MIT Press, 1989), 45.

5 Philippe Aghion and Peter Howitt, "A Model of Growth through Creative Destruction," *Econometrica* 60, No. 2 (March 1992): 323-351.

fragile financial markets this can lead to liquidity crises and even recession. Structural and long-term factors also influence economic growth, in addition to nominal factors. Openness promotes technology transfer, efficiency, and global value chain integration.[6] Openness contributes to long-run GDP growth through innovation and competitiveness in developing and developed economies, particularly G-20 economies[7] but its impact could be affected by environmental capacity and structural readiness.[8] Urbanization leads to economies of agglomeration, migration, and innovation.[9]

Greater market and skills enhance productivity.[10] Environmental pollutants, such as CO_2, increase with fast urbanization.[11] Urbanization boosts productivity but causes environmental problems due to industrial development and

6 David Dollar and Aart Kraay, "Trade, Growth, and Poverty," *Economic Journal* 114, No. 493 (February 2004): F22–F49. See Also Jeffrey D. Sachs and Andrew M. Warner, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity* 1995, No. 1 (1995): 1–118.

7 Yang Jiang, Zhixuan Zhou, and Cheng Liu, "Trade Openness, Technological Innovation, and Economic Growth: Evidence from G-20 Countries," *Economic Research-Ekonomska Istraživanja* 35, No. 1 (2022): 1–20.

8 Md. Mizanur Rahman, "Environmental Degradation, Trade Openness and Economic Growth: Evidence from Selected South Asian Countries," *Journal of Environmental Management* 270 (September 2020): 110–118.

9 Jason Henderson, "Building the Rural Economy with High-Growth Entrepreneurs," *Economic Review* (Federal Reserve Bank of Kansas City) 87, No. 3 (2002): 45–70.

10 Danny Canning, Marianne Fay, and Enrico Perotti, "Infrastructure and Growth: A Review of the Empirical Literature," in *The New Microeconomics of Infrastructure* (Washington, DC: World Bank, 2008), 5–34.

11 Ashfaq Anwar, Muhammad Younis, and Izzat Ullah, "Impact of Urbanization and Economic Growth on CO_2 Emission: A Case of Far East Asian Countries," *International Journal of Environmental Research and Public Health* 17, No. 7 (2020): 25-31.

electricity consumption.[12] Energy use and investment are also important for growth. Infrastructure and equipment investments also increase growth and productivity.[13] As we see in Pakistan, inefficient or erratic investments can be a problem in this link, particularly in the short run.[14] Energy use increases productivity and transport in developing countries.[15] An inefficient energy supply negatively effects on productivity and economic growth.[16] This growth process is complicated by environmental quality issues, especially CO_2 emissions.

There is an Environmental Kuznets Curve (EKC) for emissions, which grow with output but diminish with income. But the increased emissions found in developing countries using non-renewable energy resources can increase the marginal cost of production, which hinders growth.[17] This suggests the importance of development with environmental sustainability. Although extensively studied, the literature on macroeconomic variables and growth is scant. Many empirical studies use linear models based on the assumption of linearity (symmetric effects) of variables. This

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12 J. Zhu *et al.*, "Inflation Targeting and Economic Stability: A Comparative Analysis," *International Journal of* Central Banking 23, No. 3 (2022): 101-125.

13 N. Gregory Mankiw, David Romer, and David N. Weil, "A Contribution to the Empirics of Economic Growth," Quarterly Journal of Economics 107, No. 2 (May 1992): 407-437.

14 Abdul Qayyum and Adnan Haider, "Foreign Direct Investment, Financial Development and Economic Growth: Empirical Evidence from Pakistan," *Journal of Economic Cooperation and Development* 33, No. 4 (2012): 1–24.

15 David I. Stern, "A Multivariate Cointegration Analysis of the Role of Energy in the U.S. Macroeconomy," *Energy Economics* 22, No. 2 (April 2000): 265–283.

16 Ugur Soytas and Ramazan Sari, *"Energy Consumption and GDP: Causality Analysis in G7 Countries and Some Developing Countries," Energy Economics 25, No. 1 (January 2003):33–37.*

17 Muhammad Shahbaz and Muhammad Shahbaz Shazi, "Financial Development and Economic Growth: The Role of Stock Markets in Pakistan," *Economic Modelling* 29, No. 4 (July 2012): 1121–1130.

is not necessarily the case. One example is when inflation beyond a certain threshold has a larger negative effect on growth than disinflation does.[18] It shows some asymmetries not captured by standard models. This can be avoided with improved econometric techniques. Pesaran *et al.*[19] used autoregressive Distributed Lag (ARDL) approaches long-run relationships regardless of variable type. Building on this, Shin *et al.*[20] developed the Nonlinear ARDL (NARDL) model to account for asymmetries by splitting the explanatory variables into positive and negative changes.

This model allows for a better understanding of the impact of inflation, exchange rates, interest rates, and FDI on economic growth. Given the macroeconomic instability of Pakistan, which is associated with substantial fluctuations in nominal variables, it is necessary to examine their levels and extraction about their equilibrium. Most prior research neglects both the joint and asymmetric effects. This limits knowledge of the macroeconomic factors influencing growth. Therefore, this paper analyses the asymmetric impact of inflation, exchange rate, interest rate and FDI on the economic growth in Pakistan. It also discusses long-term factors such as trade liberalization, urbanization, capital deepening, energy consumption, and environmental degradation. The paper uses a nonlinear ARDL approach to study the impact of positive and negative shocks to equilibrium. This paper should have important policy

18 Michael Bruno and William Easterly, "Inflation Crises and Long-Run Growth," *Journal of Monetary Economics* 41, No. 1 (February 1998): 3-26.

19 M. Hashem Pesaran, Yongcheol Shin, and Richard J. Smith, "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics* 16, No. 3 (May/June 2001): 289–326.

20 Yongcheol Shin, Byungchul Yu, and Matthew Greenwood-Nimmo, "Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework," in Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications, ed. Robin C. Sickles and William C. Horrace (New York: Springer, 2014), (281-314).

implications. Knowledge of asymmetric effects would help policymakers such as the State Bank of Pakistan design effective macroeconomic policies. Pakistan requires equilibrium, constancy and stability of key variables to achieve sustainable and inclusive growth.

Literature Review

The study of macroeconomic drivers of economic growth in Pakistan, such as inflation, exchange rates, energy use, and foreign direct investment, is comprehensive. These papers employ threshold regression, OLS, ARDL, and nonlinear models to model both linear and nonlinear developmental dynamics of economic growth between 1970 and 2023. There is abundant literature on the relationship of inflation and growth. Inflation Threshold regression[21] analyzes the dynamics of inflation 1973-2023 and identifies both important thresholds of 9.3 percent (CPI) and 9.6 percent (WPI). They discovered that inflation within these levels does not have a significant impact on economic growth, but beyond these levels, the economy shrinks drastically. OSL estimate according to Imran Khan *et al.*[22] regarding the association between inflation and growth between 1970 and 2019 reveals that there is a positive correlation that is not significant until 7.5 but beyond that point, inflation becomes deleterious. Mohsin and Abdelhaq[23] established a nonlinear relationship between inflation and growth and pointed out that moderate inflation is neutral to growth, whereas extreme inflation is detrimental to investment and output.

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21 A. Arshad and M. Hayat, "Inflation Threshold Regression and Its Impact on Economic Growth (1973–2023)" (unpublished manuscript, 2025).

22 I. Imran Khan, I. Ahmad, and Faiza, "Inflation and Economic Growth in Pakistan: Threshold Effects and Policy Implications," *Social Science Review Archives* 3, No. 3 (2025): 1221–1235.

23 Mohsin S. Khan and Abdelhak S. Senhadji, "Threshold Effects in the Relationship between Inflation and Growth," IMF Working Paper No. 00/110 (Washington, DC: International Monetary Fund, 2000), 1.

Exchange rate dynamics are another crucial economic factor. Kashif and Khalid[24] demonstrate that exchange rate misalignment and volatility are detrimental to economic growth, particularly when it is sustained. Ali and Nadeem[25] and Zeb and Mahmood[26] present studies that attribute overvaluation to decreasing export competitiveness and investment, and mild undervaluation to enhancing trade performance and growth. To ensure macroeconomic stability, Fida *et al*.[27] and Hyder and Mehboob emphasize maintaining exchange rates near equilibrium. According to Shair *et al*.[28], textile exports increase more in response to currency depreciation as opposed to currency appreciation. Literature also places increased attention on energy use and environmental factors. The authors of this article Zafar *et al*.[29] conclude that positive shocks to the consumption of renewable energy can lead to sustainable growth, whereas negative shocks prevent it, emphasizing energy-efficiency actions.

24 M. Kashif and S. Khalid, "The Impact of Firm-Specific Factors on Stock Prices: New Insight from Emerging Markets of Asia," *Journal of Accounting and Finance in Emerging Economies* 8, No. 1 (2023): 1-14.

25 W. Khalid, J. Iqbal, and N. Nasir, "Do Real Exchange Rate Misalignments Have Threshold Effects on Economic Growth? Asymmetric Evidence from Pakistan," *Economic Change and Restructuring* 57, No. 6 (2024): 1.

26 S. Zeb and Z. Mahmood, "Real Exchange Rate Misalignment and Its Impact on the Pakistan Economy," S3H Working Paper Series No. 3 (Islamabad: School of Social Sciences and Humanities, National University of Sciences and Technology, 2022), 1.

27 B. A. Fida, M. S. Khan, and S. Javed, "Determinants of Real Exchange Rate in Pakistan: An Empirical Analysis," *Lahore Journal of Economics* 17, No. 2 (2012): 1–24.

28 W. Shair, "Non-linear Effects of Inflation Uncertainty on Economic Growth," Pakistan Development Review 63, No. 1 (2024): 45–68.

29 F. Zafar, A. G. Naveed, and S. Shaheen, "Asymmetric Impact of Monetary Policy on Output Volatility: Evidence from Asian Economies," Journal of Applied Economics 28, No. 1 (2025): 1-20.

Abbasi *et al.*[30] cite as evidence that energy usage and industrialization positively correlate with long-term economic growth, whereas urbanization and CO_2 emissions have counter-intuitive effects. The importance of sustainable energy policies is that Rehman *et al*[31] demonstrate that adverse energy consumption shocks damage GDP in the long-term. According to Shah *et al.*[32], the increased carbon emissions have detrimental effects on GDP during periods of economic expansion, meaning asymmetric relationships. Tanveer *et al*[33] report that positive and negative energy shocks are known to raise short-term CO_2 emissions, but only the negative energy shocks reduce long-term emissions. Both FDI and financial considerations effect economic growth. Ali *et al*[34] point out that FDI has varied outcomes depending on environmental and structural conditions, and that CO2 emissions result from energy use and economic growth.

30 R. Qasi *et al.*, "How Energy Consumption, Industrial Growth, Urbanization, and CO_2 Emissions Affect Economic Growth in Pakistan? A Novel Dynamic ARDL Simulations Approach," *Energy Reports* 7 (2021): 182–192.

31 A. Rehman *et al.*, "The Dynamic Impacts of CO_2 Emissions from Different Sources on Pakistan's Economic Progress: A Roadmap to Sustainable Development," *Environment, Development and Sustainability* 23, No. 12 (2021): 17857-17880.

32 I. H. Shah *et al.*, "Cement Substitution with Secondary Materials Can Reduce Annual Global CO_2 Emissions by up to 1.3 Gigatons," Nature Communications 13, No. 1 (2022): 5758.

33 Z. Tanveer *et al.*, "Inflation, Political Stability, and Economic Growth in Emerging Markets," Economic Research–Ekonomska Istraživanja 35, No. 1 (2022): 3121-3135.

34 Ali, M. U., Z. Gong, M. U. Ali, X. Wu, and C. Yao. "Fossil Energy Consumption, Economic Development, Inward FDI Impact on CO2 Emissions in Pakistan: Testing EKC Hypothesis through ARDL Model." *International Journal of Finance & Economics* 26, No. 3 (July 2021): 3210–21.

According to Mansoor and Bibi[35], long-term FDI increases GDP, but inflation and exchange rate fluctuation are detrimental to it. In international circles, as observed by AM Marcel[36], the contribution of FDI to growth is at times lagging and thus necessitates dynamic modeling. Jui *et al.* demonstrate that FDI and remittances are positive drivers of Pakistani GDP, although not in every South Asian economy. Numerous empirical studies are today modelling complex economic nexuses by employing nonlinear and asymmetric structures. Rehman *et al*[37] determined that the nonlinearity between the financial development factor, urbanization factor, and energy use in correlating with CO2 emissions is based on the quantile ARDL model. Abbasi *et al*.[38] propose that positive renewable energy shocks and negative nonrenewable energy shocks increase and decrease the performance of the economy, respectively.

Hameed *et al*.[39] opine that money supply and exchange rate volatility encourage inflation in Pakistan, whereas Jehan and Irshad[40] opine that exchange rate misalignment is a factor

35 M A. Mansoor and T. Bibi, "Dynamic Relationship between Inflation, Exchange Rate, FDI and GDP: Evidence from Pakistan," *Acta Universitatis Danubius. Œconomica* 15, No. 2 (2018): 1.

36 D. T. Am Marcel, "The Determinant of Economic Growth Evidence from Benin: Time Series Analysis from 1970 to 2017" (unpublished manuscript, 2019), 1.

37 S. Rehman *et al*., "Impact of Financial Development, Energy Consumption and Urbanization on CO_2 Emissions from Buildings Using Quantile ARDL Model," *Journal of Infrastructure, Policy and Development* 7 (2023): 2166.

38 K. R. Abbasi *et al*., "How Energy Consumption, Industrial Growth, Urbanization, and CO_2 Emissions Affect Economic Growth in Pakistan? A Novel Dynamic ARDL Simulations Approach," *Energy Reports* 7 (2021): 182–192.

39 M. A. Hameed, M. M. Rahman, and R. Khanam, "Analyzing the Consequences of Long-Run Civil War on Unemployment Rate: Evidence from Afghanistan," *Journal of Applied Economic Sciences* 18, No. 1 (2023): 126–140.

40 Z. Jehan and I. Irshad, "Testing the Validity of the Fisher Hypothesis: Evidence from South Asian Economies," *Journal of Applied Economics and Business Studies* 4, No. 2 (2020): 32–48.

that impacts investment and economic growth despite financial development. Halim and Huq I.[41] and Wang *et al.*[42] focus on the role of trade openness and logistical efficiency as drivers of growth, and Zhang *et al.*[43] on the geopolitical issues in the energy markets and macroeconomic stability. According to Banaga and Badawi[44], monetary and exchange rate policy requires stability throughout the economic growth in the long-term. Extensive literature has a big knowledge gap. Most of the research observes the components of individual economic growth such as inflation, energy usage and currency rates without relating them to each other. Most analyses consider linear models of the effect, which should be symmetric, implying that positive and negative shocks may not have the same impact on economic growth. These assumptions can lead to incomplete or biased conclusions because Pakistan is economically volatile and structurally complex. Thus, a nonlinear integrated framework of analysis that consider the cumulative and intersecting effects of significant macroeconomic variables is required. The Nonlinear Autoregressive Distributed Lag (NARDL) model can address this gap by decomposing variables into positive and negative changes and approximating their short- and long-term impacts. The method assists policymakers to comprehend dynamics of economic growth and implement

41 M. A. Halim and S. Moudud-Ul-Huq, "Green Economic Growth in BRIC and CIVETS Countries: The Effects of Trade Openness and Sustainable Development Goals," *Heliyon* 10, No. 9 (2024): 1.

42 X. Wang, H. Zhang, and M. Shi, "The Mediating Role of Supply Chain Digitization in the Relationship between Cross-Border E-Commerce Development and Regional Economic Growth," *Finance Research Letters* 75 (2025): 106830.

43 S. Zhang, B. K. Sovacool, and C. Wei, "Do Clean Energy Transitions Enhance Global Energy Security? A Comparative Analysis of Trends and Tradeoffs across Eight Major Economies, 1990-2020," *Energy Policy* 212 (2026): 115164.

44 Banaga, S., & Badawi, O. (2014). Application of Islamic consumer theory: A study in Bangladesh. *Global Review of Islamic Economics and Business, 2*(1), 69–83.

relevant policies in the evolving macroeconomic background in Pakistan.

Definition and Description of Variables

This study analyzes the relationship between economic growth and macroeconomic drivers in Pakistan from 1980 to 2024, using real GDP as the dependent variable. Key explanatory variables include inflation, exchange rate, foreign direct investment, capital formation, urban population, energy use, and CO_2 emissions, with data sourced from the World Bank and Pakistan Economic Survey (Table 1).

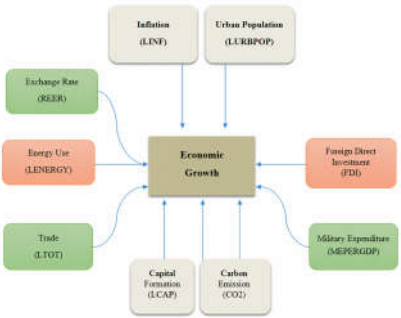
TABLE 1: DEFINITIONS AND SOURCES OF DATA

Variables	Abbreviations	Descriptions
Economic growth	LGDP	GDP per capita (constant US$)
Energy use	LENGU	Total energy consumption
Urban population	LURBPOP	Total number of people residing in urban areas of the country
Inflation	LINF	Annual percentage change in customer price index reflects the rise in cost of goods and services.
Exchange rate	LREER	Deviation of exchange rate
Trade	LTOT	Trade index
Foreign direct investment	FDI	Net inflow of investments
Military expenditure	MEXP	Military expenditure per GDP
Carbon-emissions	CO2	Carbon dioxide emissions (Mt)
Capital	LK	Total physical stock of capital in economy

Theoretical Background

This paper is theoretically structured around the New Keynesian Economics, which reinforces the importance of nominal rigidity and macroeconomic stability to economic performance. The idea is that fluctuations in key nominal variables, such as inflation and exchange rates, could misrepresent price signals, increase uncertainty, and adversely effect on investment decisions.[45] Exchange rate fluctuations also affect trade competitiveness and external equilibrium.

Conceptual Framework



Besides, the roles of capital accumulation, technological improvement, and human development as espoused by the Neoclassical Growth Theory[46] and Endogenous Growth

45 Fischer, "The Role of Macroeconomic Factors in Growth" and Barro, 1995)

46 Robert M. Solow, "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70, No. 1 (February 1956): 65.

Theory, also underscore the importance of these in achieving long-term economic growth. Carbon emissions are included as an environmental impact factor that is integrated according to the hypothesis of the Environmental Kuznets Curve, which relates economic activity to environmental degradation.[47]

This paper is an attempt to integrate macroeconomic, structural and environmental perspectives in explaining the determinants of economic growth in Pakistan.

Econometric Model

This paper employs the Nonlinear Autoregressive Distributed Lag (NARDL) model to analyze the asymmetric effects of macroeconomic variables on economic growth, expanding upon the ARDL framework. It examines inflation, currency rate, and FDI through positive and negative partial sums to determine their respective impacts. Unit root tests confirm the integration order of variables, while bound testing establishes long-term cointegration. The model employs the Akaike Information Criterion for optimal lag selection and utilizes an error correction model (ECM) to assess short-run dynamics and long-run relationships, ensuring reliability through diagnostics for serial correlation and stability. The study demonstrates how ARDL and NARDL techniques can effectively handle small sample sizes and mixed integration orders in the context of Pakistan.[48]

The functional form of the model is demonstrated as follows:

$$LGDP = f(LINF, REER, LURB, LTOT, MEXP, CO2, LK, FDI, LENG) \quad (1)$$

The final NARDL specification of Economic Growth can be written as:

47 Gene M. Grossman and Alan B. Krueger, "Economic Growth and the Environment," *Quarterly Journal of Economics* 110, No. 2 (May 1995): 353.

48 Pesaran, *et al*., "Bounds Testing Approaches to the Analysis of Level Relationships".

$$LGDP_t = n_0 + \sum_{i=1}^{p} n_1 LGDP_{t-i} + \sum_{i=0}^{q} n_2 INF_{t-i}^{+} + \sum_{i=0}^{q} n_3 INF_{t-i}^{-} + \sum_{i=0}^{q} n_4 REER_{t-i}^{+} + \sum_{i=0}^{q} n_5 REER_{t-i}^{-} + \sum_{i=0}^{q} n_6 FDI_{t-i}^{+} + \sum_{i=0}^{q} n_7 FDI_{t-i}^{-} + \sum_{i=0}^{q} n_8 LTOT_{t-1} + \sum_{i=0}^{q} n_9 LURB_{t-1} + \sum_{i=0}^{q} n_{10} MEXP_{t-1} + \sum_{i=0}^{q} n_{11} LENG_{t-1} + \sum_{i=0}^{q} n_{12} LK_{t-1} + \sum_{i=0}^{q} n_{13} CO2_{t-1} + u_t \quad (8)$$

Where GDPt is the dependent variable in this model, INF_t, $REER_t$, $LURB_t$, $LTOT_t$, $MEXP_t$, $CO2_t$, LK_t, FDI_t, $LENG_t$ represent the explanatory variables and contain time series ranging from 1980 to 2025.

- n = short-run coefficients
- λ = long-run coefficients
- p = lag length of dependent variables
- q = lag length of independent variables
- p_t = error term

This NARDL model allows the understanding of both short-run and long-run asymmetric impacts of Nominal variables and other elements on economic growth, highlighting whether positive and negative changes in main indicators have diverse effects on economic growth in Pakistan.

Results and Discussions

Descriptive Statistics

Table 2 presents the descriptive statistics of the variables. Economic growth (LGDP) shows a stable pattern with low variability (SD = 0.099) and a normal distribution (JB = 0.437). Inflation (INF), terms of trade (LTOT), urbanization (LURB), capital (LK), energy consumption (LENG), and CO_2 emissions also exhibit relatively low dispersion and are approximately normally distributed, as indicated by insignificant JB probabilities. Manufacturing exports (MEXP) display comparatively higher volatility, suggesting fluctuations in export performance. In contrast, FDI shows the highest variability (SD = 0.626) and strong positive skewness (2.22), with a significant JB value, indicating non-normality and the presence of extreme variations. Overall, most variables are stable and normally distributed, except FDI, which reflects asymmetric behavior.

TABLE 2: DESCRIPTIVE STATISTICS

Variables	Mean	Median	Max	Min	S.D	Skew	Prob.
LGDP	3.0519	3.0249	3.2158	2.8631	0.0994	0.00746	0.4374
INF	0.8389	0.8807	1.3071	0.4030	0.2241	-0.2638	0.3848
LTOT	2.0151	2.018	2.338	1.994	0.0009	-0.5327	0.1895
LURB	1.5200	1.5234	1.5854	1.3316	0.0636	-0.6812	0.1895
MEXP	4.7478	4.0914	6.9916	2.8014	1.4808	0.2188	0.0723
LK	1.2289	1.2439	1.3156	1.1118	0.0477	-0.2749	0.3914
LENG	2.6087	2.6144	2.6727	2.5273	0.0426	-0.4044	0.2025
CO2	123.32	113.94	236.74	29.019	61.492	0.1419	0.2679
FDI	0.7903	0.6160	3.0357	0.1026	0.6256	2.2246	0

Stationarity Testing

Unit root tests results in table 3, especially the results of PP and ADF, show a mixed order of integration between the variables, indicating the existence of both stationary I (0) and non-stationary I (1) trend altogether in the dataset. In sum, the coexistence of I (0) and I (1) variables justify the suitability of the ARDL and NARDL modelling technique.

TABLE 3: UNIT ROOT TEST RESULTS

	PP		ADF		
Variables	Level	1st Difference	Level	1st Difference	Decision
LGDP	-0.53	-6.99***	-0.17*	-6.31***	I (0)
LINF	2.29	-4.32	2.21	1.65*	I (1)
LREER	-1.64	-2.01***	-1.6	-2.12***	I (1)

LTOT	-1.41	-5.89***	-1.43	-6.03***	I (1)
LURB	-1.23	-3.45***	-0.73**	-2.86**	I (0)
MEXP	-1.09	-6.7***	-4.56*	-4.47***	I (0)
LK	-13.15***	-3.67*	-2.31	-1.20	I (0)
LENG	3.8	-6.93***	2.30	-1.40	I (1)
CO2	-4.19***	-4.20***	4.18***	-4.18***	I (0)
FDI	-1.53	-8.99***	-1.67*	-4.21***	I (0)

Note: In the unit root test, the null hypothesis is not accepted at 1%, 5%, or 10% significance levels. Indicators added at order one is represented as I (1).

Bounds Test Results

Table 4 presents the ARDL bounds test results for cointegration. The F-statistic (35.369) is substantially higher than the upper critical bound (I(1)) at all conventional significance levels (10%, 5%, 2.5%, and 1%), confirming the existence of a long-run relationship among the variables. Similarly, the t-statistic (−11.470) is more negative than the corresponding critical values, further supporting rejection of the null hypothesis of no level relationship.

These results provide strong evidence of cointegration, indicating that the variables move together in the long run. Therefore, the application of the ARDL model and the error correction framework is appropriate for analyzing both short-run dynamics and long-run equilibrium relationships.

TABLE 4: BOUNDS TEST RESULTS

F-Bounds Test – Null Hypothesis: No level relationship

Test Statistic	Value	Significance Level	I(0)	I(1)
F-statistic	35.369	10%	1.6	2.72
K	11	5%	1.82	2.99

		2.5%	2.02	3.27
		1%	2.26	3.6

t-Bounds Test – Null Hypothesis: No level relationship

Test Statistic	Value	Significance Level	I(0)	I(1)
t-statistic	-11.47002	10%	-1.62	-4.42
		5%	-1.95	-4.76
		2.5%	-2.24	-5.06
		1%	-2.58	-5.44

NARDL Short Run Results

Table 5 shows the results of short run NARDL model that highlights the impact of macroeconomic variables on the economic growth of Pakistan. Increasing the LINFLATION_POS at the rate of 1% for short run will improve the GDP at the coefficient of 0.069 or 6.9% proves that it enhances the economic growth for short run. It is evident from Khan and Sinhadji that short run inflation is always helpful for growth.

If there is a real effective exchange rate LREER_POS at the rate of 1% will increase the economy by 40.7% in the short run. Increasing investment behavior, import channels and changes in competitiveness can transmit the shocks quickly is indicated by this large value of the coefficient states. The deterioration in 1% reduces the TOT term of trade lowers production by 61%. It gives the evidence of effects of external shocks of pricing on the economic growth of Pakistan and has highly strong and damaging impact on it. Both these are explained by Jehan and Irshad and Fida work on the real effective exchange rate changes in the competitiveness and misalignment from directly impacts the economic growth of Pakistan. Fida cleared that import dependence and concentration on exports causes TOT fluctuation and it directly impacts the GDP.

1% rise in FDI_POS increases the GDP by 4.3%. Foreign capital inflow enhances the economy by financial development and channels that are highly competitive Jehan and Irshad. Increasing the level of carbon emissions in the form of carbon dioxide CO2 at the rate of 1% reduces the output by 0.001% but has small but highly significant and adverse effects on economic growth. it is evident from the work of Rodrick that unstable environmental situations can hinder the economic growth even at smaller scale.

TABLE 5: NARDL SHORT RUN RESULTS

Variables	Coefficient	St. Error	T. Value	Prob.
C	1.014	0.53	1.97	0.052
LGD(-1)*	1.299	0.15	-8.91	0.000
LENG**	0.301	0.16	1.85	0.069
LINF POS(-1)*	0.069	0.02	4.82	0.000
LINF NEG**	0.006	0.01	0.65	0.513
LREER_POS(-1)	0.407	0.13	3.22	0.004
LREER_NEG**	-0.066	0.04	-1.72	0.101
LTOT**	-0.61	0.16	-3.54	0.002
LURB**	2.012	0.38	5.52	0.000
LK**	0.033	0.04	5.76	0.000
FDI_POS**	0.043	0.01	5.87	0.000
FDI_NEG**	0.009	0.03	2.21	0.039
CO2**	-0.001	0.00	-2.43	0.024
MEXP**	0.031	0.029	6.15	0.000
D(INF_POS)	0.021	0.01	1.52	0.145

D(LREER_POS)	0.106	0.09	1.47	0.157
CointEq (-1)*	-8914.000	0.62	-14.53	0.000

Model Summary:

$R^2 = 0.9712 \mid \text{Adj.}\, R^2 = 0.9629 \mid S.E\ of\ Regression = 0.001292$

Akaike Info Criterion = 10.522 | Schwarz Criterion = -9.466 | Log Likelihood = 164.05 Durbin-Watson = 2.376 | Observations = 29

NARDL Long-Run results

The long-run results of asymmetric analysis indicate that a positive co-efficient of inflation is statistically significant as increase above 1%. 1% change in inflation rate will show the co-efficient of 0.043 that shows dependent variable GDP will increase by 4.3%. At this point, it is highly significant and represents positive long run elasticity. Increase in inflation above 1% shows that it is asymmetric, strong and statistically highly significant. This is evident from the work of Khan and Senhadji that was bases on threshold in inflations and its impact on GDP and overall economic growth and stated that increase in positive coefficients is alongside the moderate inflation and it is not always harmful. In contrast to this, reduction in 1% inflation increases the GDP just by 0.34%. It means reduction in inflation rate does not significantly impact the economic growth on long run in this model. That shows the asymmetry and is clear from Khan and Senhadji, where they set a threshold below which there is no significant impact on the economy. Thus, it is evident from the model and past research that increasing inflation above the threshold has higher impact and below which is not significant.

Similarly, the movement either positive or negative in foreign direct investment is also important for the long run growth but it varies in the magnitude. Generally, change in the direction matters and magnitude can be changed. Increase in 1% in foreign direct investment will raise the GDP with a coefficient of 0.031 or 3.1% (t=6.44, p=0.00). It shows that the increase in FDI has high impact on the GDP than

decrease in FDI. While decrease in the same percentage increases the GDP by the coefficient of 0.004 or 0.47% (t=2.38, p=0.03), showing the positive effect but it has very little impact on the economic growth. Overall increase in FDI is more significant and has greater impact on the growth than reduction in FDI. It is also emphasized by Jehan and Irshad and Rodrik who stated about the foreign investments and structural performances in the economic performances.

Moreover, in positive REER partial sum, increase in 1% in real effective exchange rate increase the GDP by the coefficient of 0.299 or 29.9 % (t=3.7, p=0.001) shows the strong, meaningful and positive impact on long run. It shown that positive shocks or misalignment in positive direction of REER partial sum have high and significant impact on Pakistan's economic growth. Jehan and Irshad stated that the deviations from the equilibrium value will have asymmetric impact on the economic growth depending upon the direction and upwards movement will have far significant impact on the economic growth of Pakistan. While 1% decrease in REER it will affect the economic growth at the coefficient of -0.051 or decrease the GDP by 5.1%. (t=-1.83, p=0.083) on long run, showing the negative and weak impact on the GDP. It means when REER falls in a downward direction, the economy will face decline in the output. But overall effect is smaller than the positive REER partial sum. The changes in the magnitude and direction (signs) show the asymmetric exchange rate dynamics and support the evidence of Fida, Khan and Javed. They stated that both undervaluation and overvaluation have strong impact on the economy, overvaluation has significant impact on the GDP. Later Hyder and Mehboob cleared that the deviations in REER effect the competitiveness verily according to the movement of direction. The negative REER partial sum has weaker and marginal impact on the economic growth of Pakistan.

In addition, increasing long run capital by 1% increases the GDP at the coefficient of 0.181 or 18.1% (t=5.96, p=0.00). it indicates the string and significant impact of positive

movement on the economic growth of Pakistan further supports the idea and work of proper investment led policies and capital broadening to increase the long-term output and have strong long run elasticity respectively. These findings support Annicchiarico, Pelloni and Rossi. They highlighted proper capital allocation is the key to economic growth and stated how investments improve the ability of economy to cope with the fluctuations and shocks and sustain economic growth for long term. Hence, it is proved that long term capital formation supports literature based on capital allocation and investment policies to boost the economy.

In addition, increasing 1% energy level increases the GDP at the coefficient of 0.310 or 31% (t=1.85, p=0.0796) as long run output. It shows that it is highly significant and strong at this level of energy use. It is marginally significant at 10% increase in energy level and is not stronger at 5%. It is evident from Rodrik the effect of structural factors that include productivity channel and energy effect nominal variables affect the GDP and economic growth by increasing the productivity capacity.

Terms of trade are another factor and its impact on economic growth cannot be neglected. Increase in 1% of terms of trade will decrease the coefficient of terms of trade by -0.339 or 33.9% (t=-3.4, p=0.003). It means increasing the terms of trades to reduce the GDP by 33.9% proofs the reverse effect of terms of trade on the economy and negative price movements. As the economy is highly dependent on low value exports, production input. Terms of trade suppresses the long-term growth by increasing the cost of production and competitive weakness. It is evident from the work of Fida, Khan and Javed, where they mentioned that terms of trade effect the real exchange rate and overall economy of Pakistan get effected. Negative value of the coefficient shows there must be stable external conditions for sustained long run economic growth in Pakistan.

Increase in urban population by 1% decrease the dependent variable at the coefficient of 1.6 or 161. % (t=7.2, p=0.0000) proves that there is highly significant and strong relationship between urban population and economic growth. The functions of cities in improving labor productivity, enhancing the technological sector, broadening the services, expanding industry and overall economic growth are stated by the value of elasticity. Hence it is significant to have labor mobility, urban infrastructure, developments based on cities to have sustained economic growth in Pakistan for long run period. This idea is also supported by Rodrik, that transformation in structure and urbanization have the pivotal role to boost the returns to the capital.

Finally, increasing the level of carbon emission in the form of CO2 will create a negative coefficient on long by -0.0001 showing increase in the CO2 level by 1% decrease the dependent variable GDP by 0.01% highlights the importance of having stable environmental conditions to have long run economic performances. There is always a negative value of magnitude due to the adverse effects from environment in the form of pollution that hinders economic growth by reducing labor productivity, human health and agricultural production necessary for the economy. It is also supported by Rodrik, it states environment has key role in enhancing economic performance. Long run economic growth needs cleaner environment and environment friendly policies as it is evident from the negative coefficient above.

TABLE 6: LONG RUN NARDL RESULTS

Variables	Coefficient	Std. Error	T. Statistic	Prob.
LENG	0.310	0.119	1.84	0.08
LINF_POS	0.043	0.0079	5.7	0.00
LINF_NEG	0.0034	0.0055	0.65	0.52
LREER_POS	0.299	0.09	3.7	0.001

LREER_NEG	-0.051	0.03	-1.8	0.08
LTOT	-0.339	0.13	-3.4	0.03
LURB	1.601	0.22	7.2	0.00
LK	0.181	0.03	5.96	0.00
FDI_POS	0.031	0.004	6.44	0.00
FDI_NEG	0.004	0.002	2.38	0.03
CO2	0.0001	0.000	-2.59	0.02
MEXP	0.016	0.002	6.988	0.000

Diagnostic tests

Table 7 contains the main diagnostic test result. The probability of the Breush Godfrey serial Correlation LM test is more than 0.05 so we do not reject the null hypothesis and concluded that there is no serial correlation between variables. To determine the heteroscedasticity, Breusch-Pagan-Godfrey test and the value of probability is greater than 0.05 so we do not reject the null hypothesis there is no heteroscedasticity between variables. Ramsey RESET test is used to check for any specification bias, the probability is greater than 0.05 and we do not reject the null and conclude that specification bias is not found.

TABLE 7: SUMMARY OF DIAGNOSTIC TEST RESULTS

Item	Test Applied	Value	Prob. (p-value)
Serial Correlation	Breusch-Godfrey Serial Correlation LM Test	2.23	0.15
Heteroskedasticity	Breusch-Pagan-Godfrey Test	0.62	0.87
Specification Bias	Ramsey RESET Test	0.017	0.91

Source: Author's Estimation by means of Eviews (2025)

Stability Test

We use CUSUM and CUSUM square test to assess the stability of the confinement of the variables and to find if some structural breach found in the NARDL model. This test was initially introduced by Brown *et al*. In figure 2 and 3 the estimated coefficients respectively tell that the statistic of both tests does not exceed the 5% limit of significance. Small changes occur in between the year but these small changes are acceptable range. The cumulative test also identifies if a regression coefficient is suddenly changing. (Bhatti *et al*,). The finding is significantly indicated that the model is structurally consistent the model's structural stability and general quality of fit are shown by the fact these two-test fall under the threshold constraints of 5%.

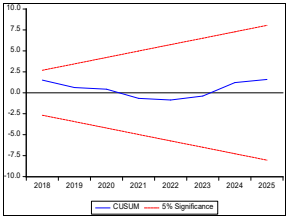


Figure 2

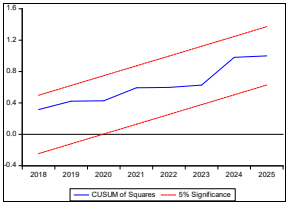


Figure 3

Conclusion

This study concludes that economic growth in Pakistan is influenced by a complex interaction of macroeconomic, structural, and environmental factors. The findings highlight fluctuations in key nominal variables such as inflation, exchange rate, and foreign direct investment (FDI) along with structural determinants like energy consumption, industrial growth, trade openness, urbanization, and environmental conditions, jointly shaped the trajectory of per capita GDP.

Using the Nonlinear ARDL (NARDL) framework, the study captures both short-run and long-run dynamics, as well as asymmetric effects of positive and negative shocks. The results reveal that energy consumption exerts a strong and positive influence on economic growth, reflecting its central role as a productive input in industrial and service sectors. Both short-term increases in energy availability and sustained long-term supply significantly enhance production capacity and overall economic output.

Similarly, trade openness and urbanization positively influence growth by enhancing market integration, resource allocation, and agglomeration economies. In contrast, inflation demonstrates a nonlinear and asymmetric relationship with growth. Moderate inflation appears less harmful, while higher inflation significantly reduces purchasing power, increases uncertainty, and discourages investment. Exchange rate fluctuations also exhibit asymmetric effects; depreciation tends to improve export competitiveness, whereas excessive appreciation undermines external balance and economic performance.

Environmental factors, particularly carbon emissions, introduce important trade-offs. While economic expansion is often associated with increased emissions in the short run, long-term environmental degradation can constrain sustainable growth. The results emphasize the need to balance economic development with environmental sustainability. Overall, the findings confirm that economic

growth is not driven by a single factor but rather by a network of interconnected forces. The asymmetric nature of macroeconomic variables underscores the importance of considering both the magnitude and direction of changes when analyzing economic performance.

Policy Recommendations

Based on empirical findings, several policy implications emerge. First, maintaining macroeconomic stability should be a central priority. Policymakers should adopt coordinated fiscal and monetary policies aimed at stabilizing inflation, exchange rates, and interest rates. Strengthening the role of the State Bank of Pakistan through credible inflation-targeting frameworks can help anchor expectations and reduce uncertainty.

Second, exchange rate management should be market-oriented yet carefully monitored. Maintaining adequate foreign reserves and ensuring timely policy interventions can help mitigate excessive volatility and misalignment, thereby supporting trade competitiveness and economic stability. Third, structural reforms are essential to promote sustainable growth. Enhancing energy infrastructure and ensuring reliable energy supply will significantly improve industrial productivity. At the same time, policies should encourage industrial diversification, technological innovation, and export competitiveness.

Fourth, attracting stable and long-term FDI requires improving the investment climate. This includes strengthening institutional quality, simplifying regulatory frameworks, ensuring contract enforcement, and implementing transparent tax policies. Financial sector reforms, including improved credit allocation and risk assessment mechanisms, are also necessary to support productive investment.

Fifth, environmental sustainability must be integrated into economic policy. Promoting renewable energy, improving energy efficiency, and implementing environmental

regulations can help reduce carbon emissions without compromising growth objectives. Finally, long-term growth strategies should focus on human capital development, technological advancement, and export diversification. Investing in education, vocational training, and innovation will enhance productivity and reduce vulnerability to external shocks. In conclusion, a balanced and evidence-based policy framework that addresses both macroeconomic stability and structural transformation is essential for achieving sustainable and inclusive economic growth in Pakistan.