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Financial Development, Foreign Direct Investment, and CO_2 Emissions in Pakistan: Evidence from an Asymmetric Analysis

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ABSTRACT

This paper examines the asymmetric contribution of financial development, foreign direct investment (FDI) and economic growth to CO2 emissions in Pakistan. This study is based on the annual data of 2000-2024 and employs the Nonlinear Autoregressive Distributed Lag (NARDL) model. The short run results show that positive financial development shocks raise the level of emissions, whereas negative shocks lower the level of emissions substantially, as expected. The growth of the economy enhances the emission of CO2 and the GDP2 proves the Environmental Kuznets Curve (EKC) hypothesis. FDI is not significant in the short and long term. The results indicate that Pakistan needs to improve sustainable financial policies, increase green investments, and cleaner growth policies. The policy recommendations focus on green finance, the use of renewable energy, and controlling investment on high emission intensity projects.

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1. Introduction

In this era, the matter of climate concerned the devotion of worldwide officialdoms, environmental experts, and policy makers (Abdul et al., 2025). It is globally acknowledged that the main reason of environmental degradation due to sharp increase of greenhouse gas specifically CO_2 emissions (Khan et al., 2025). Due to massive polluting energy sources uses it is reported CO_2 emissions 1.9% increase per year. For this researcher worldwide have concentrated on finding the key determinants that impact the CO_2. So representatives can design operative plan to control the global warming (Adom, Amuakwa-Mensah, & Amuakwa-Mensah, 2020; Wang et al., 2023). Issue of environmental degradation has become a critical problem concern or emerging states such as Pakistan economy. Where fast financial development, industrial activities expansion, and foreign investment increase the demand of CO_2 emissions collectively. Increasing carbon emissions have taking health and environmental significant challenges that affect the long run sustainable development (Jamel & Zhang, 2024; Kihombo et al., 2021). Often economic growth contributes higher the CO_2 through more energy consumption, but some time eventually decreases environmental issue if the economy supported technological innovations, clean energy policies, and structure alteration known as EKC hypothesis (Çatık et al., 2024; Danish et al., 2024). Financial development can determine environmental degradation through multiple way. A strong financial system may improve the output of industrial sector and resource extraction, and hold the pollution. On other hand it may support green finance, encourage renewable energy, and increase technical efficiency (Maydybura et al., 2024). Similarly, foreign direct investment reduces CO_2 emissions with the help of pollution haven hypothesis which contribute in improvement of environment and become a reason of technology transferred (Adeel et al., 2024; Tanveer et al., 2024). A long practice in economics of environment that connect the economic growth and environment with EKC hypothesis. At early stages of development pollution increases, and at a turning point where economy shift to

services, adopt the clean technology, strong rules and regulations the pollution decline. Empirically, the EKC is measured by GDP and its square in CO_2 regressions.

Foreign direct investment and CO_2 emissions has twice effects, it can increase CO_2, in some areas like heavy industry and fossil fuel user segments (Habiba & Xinbang, 2022; Sabir et al., 2024). In coal or oil based industries investment create environment hurdles. However foreign direct investment controls the emissions when host country brings the green technology or strictly mention in their requirement about green technology for example renewable energy, like solar wind energy, etc. (Fauzel, 2017). The foreign investment based on green technology takes place the fossil fuel industries and push the local industry to follow the green technology policies and practices and it also controls the emissions (Farooq et al., 2024; Kim & Seok, 2023). Foreign direct investment share in fuel user industries and other clean energy fields must calculate to assess the net influence on CO_2. For example, if 80% of foreign investment is related to coal power stations and only 20% remaining renewable, the totally effect will be increase in environment issue. In other sides, foreign investors introduce the data on emissions or clean technology that how to reduce the environment issues (Farooq et al., 2024; Xie, Wang, & Cong, 2020). For this a highlights explains that 10% rise in foreign investment in renewable sector it leads to reduce the 5% of emissions, other side an increase in foreign direct investment in fossil fuel segment 3% occur rise in emissions. This comparative analysis would explain that FDI play a combo role in rise or fall CO_2, reliant on the mode of uses and policy (Blanco, Gonzalez, & Ruiz, 2013). The paper presents useful information on the links and points out the doubled effect of FDI of both enhancing and reducing emissions by making investments green.

The study emphasizes the need to improve the current environmental situation by promoting renewable energy use and provides practical policy recommendations. Using advanced econometric techniques, it contributes to the literature by examining the asymmetric effects of financial development, foreign direct investment, and economic growth on CO_2 emissions in Pakistan. The analysis employs annual time-series data from 2000 to 2024 and the Nonlinear Autoregressive Distributed Lag (NARDL) approach to capture positive and negative shocks in financial development and their differing impacts on CO_2 emissions. The results confirm the asymmetric role of financial development in environmental degradation. Economic growth is found to increase CO_2 emissions and validates the Environmental Kuznets Curve (EKC) hypothesis. Foreign direct investment is insignificant in both the short run and long run. Based on the differential impacts of financial development and economic growth, the study provides empirical guidance for sustainable green growth and financial policies, emphasizing the expansion of green finance, increased adoption of renewable energy, and stricter regulation of emission-intensive investments in Pakistan. The paper is designed in the succeeding way. Section 2 is a consideration of the theoretical channels and empirical literature. The data and econometric strategy is outlined in section 3. In section 4, the empirical findings, as well as strength checks, are presented. Section 5 contains a policy implications discussion and conclusion.

2. Literature Review

Numerous empirical investigations have been conducted on the correlation between financial development and CO_2 emissions, but the results are inconclusive and contradictory. These contrasting findings are mostly due to the variance in the measurement of financial development, the econometric methods and country specific factors. In general, the literature available can be divided into three major strands. The initial one implies that the FD leads to the environment enhancement over the decrease in CO_2. Many scholars have checked the influence of FDI on CO2 in past. Foreign direct investment to be an effective way for developed countries to shift technology to underdeveloped countries. As, Fatima, Arif and Arif (2026) used a standard reduced model to examine the BRICS economies and exposed that higher financial development that reduce CO_2 emissions significantly. Equally, Yousaf et al. (2024) found that FD as represented by domestic credits to private sectors is one of the factors that alleviate emissions in Malaysia. Javid and Sharif (2016) checked the diminishing impact of IQ, technological revolution and foreign direct investment on CO_2 in Asian almost 40 countries. Used GMM and data from 1996-2016 and found the positive impact of FDI inflows on CO_2 emissions. Komal and Abbas (2015) discovered the connotation of FDI and environment in MENA states between 1990-2015. Results revealed that FDI causes to CO2 in selected regions. Raza and Shah (2018) explicated that RE and modern technology both reduce the level of environment hurdle. And

foreign direct investment, financial development increases the level of environmental degradation.

Kayani, Ashfaq and Siddique (2020) found an affiliation between FDI and CO_2 some China areas and showed in these areas human resources was very low. This study was suggested at first FDI raise pollution but with the passage of improvement in technology or institution reduce the environment issue. Faheem et al. (2024) deliberated the effects of globalization, FDI inflows, and financial development on the pollution of the environment. Regarding FDI inflows, the results showed that, FDI decreased air pollution below the threshold and increased environmental pollution above the threshold. Conversely, in the lower-middle-income nations, FDI inflows led to increased levels of environmental pollution prior to and beyond the edge level. Omri et al. (2015) showed that FD and lowers CO_2 emissions in the MENA states, applying a simultaneous equation panel approach and suggest positive influence. Abbasi and Raza (2016) explored that FD in terms of stock market capital, stock revenue, and credit to the private sector was important in reducing emissions during the liberalization period 1988-2011. Similarly, Gokmenoglu and Sadeghieh (2019) established that FD by banks enhances the quality of the environment in Turkey. Yao and Tang (2021) demonstrated that a stock market-oriented financial structure is characterized by a reduced level of CO_2 in the context of G20 countries. Habiba, Xinbang and Ahmad (2021) studied more recently and verified that FD and environment in G20 when considering the use of RE and FDI. Tan et al. (2021) utilized Chinese data to estimate the ARDL model and discovered that FD has a positive impact on air quality in the short term. Conversely, the second line of literature is that FD donates to environmental deprivation through the augmentation of CO_2 emission. When Granger causality and variance decomposition methods were applied to China.

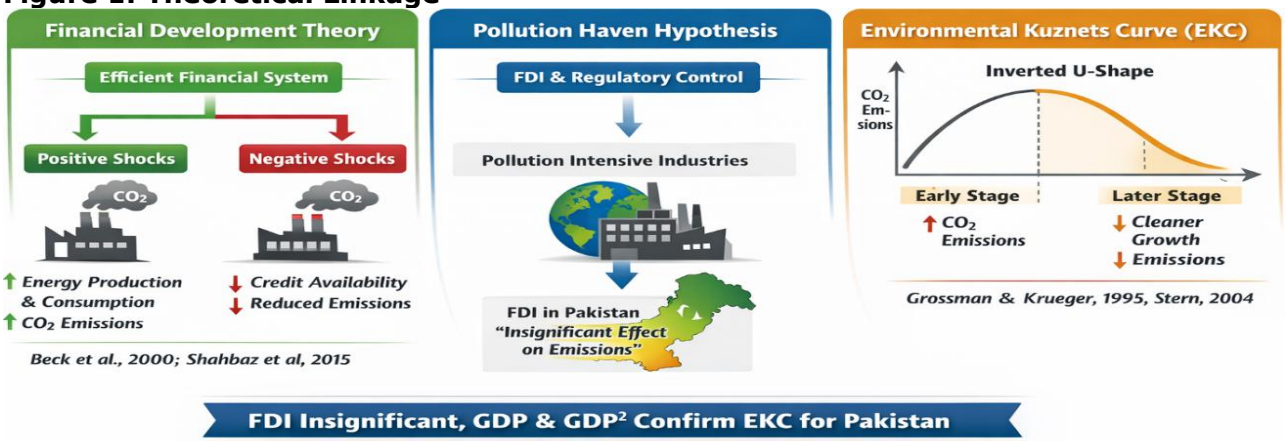
Zhang (2011) discovered that FD is a significant funder to carbon emission. On the same note, Boutabba (2014) found that financial development raises CO_2 emission in India through the ARDL and Granger causality models, with the causality being the opposite that is, finance to emissions. Mahalik and Mallick (2014) found that FD is a funder to increased carbon using FMOLS on a large panel of 129 countries. Pakistan-based evidence by Khan et al. (2025) implied that both the bank related and stock market related FD increases CO_2 emission. Maji, Habibullah and Saari (2017) also calculated that FD rises sectoral emissions especially in oil, gas, and transport sector in Malaysia. Ali et al. (2019) provide consistent results of Nigeria using the ARDL bounds testing method. Kayani, Ashfaq and Siddique (2020) affirmed a positive long-run relationship between the financial development and the CO_2 emission. The third strand finds either an insignificant or nonlinear correlation between financial development and CO_2 emissions, frequently in favor of (EKC) hypothesis. Hao et al. (2016) established that FD will first raise emissions, but later on, it will decrease, which is a case of an inverted U-shaped relationship. Equally, Shahbaz (2015) reported an inverse U-shaped affiliation among FD and CO_2 in 29 Chinese provinces. Omri et al. (2015) examined the impact of FD and suggested it had a negligible impression on environment in the MENA nations. Used the ARDL method. Dogan and Turkekul (2016) did not identify a causal relationship between financial development and CO_2 emission in the United States. Similarly, Jamel and Maktouf (2017) used panel OLS and causality tests on 40 European nations and found that no significant effect on carbon emissions.

3. Data and Methodology

3.1. Theoretical Linkage

Financial development theory postulates that an efficient financial system can inspire the economic activities by providing resource allocation and investments. In financial development positive shocks can enhance the production, and consumption of energy and it will cause to rise the CO_2 emissions. Negative shocks may limit availability of credit and slow activities of emissions (Beck, Demirguc-Kunt, & Levine, 2000; Shahbaz, 2015). The Pollution Heaven Hypothesis highlighted that foreign investment can relocate pollution intensive industries to other countries with relax environmental policies. In his study foreign direct investment insignificantly impacted the emissions in Pakistan and this is happening may be due to regulatory control and sectoral composition (Apergis, 2010; Cole, 2004). The Environmental Kuznets Curve theory shows an inverted U relation among EG and environment degradation. At start level of economic growth increase CO_2, but after touching a maximum level growth encourage clean technology, regulation of environment, and structural shifting, reduce the emissions. In this study GDP, GDP^2 prove the EKC theory for Pakistan (Grossman & Krueger, 1995; Stern, 2004).

Figure 1: Theoretical Linkage



This paper analyzes the asymmetric long-run and short-run impacts of the financial development, foreign direct investment, economic growth, and GDP square on CO_2 emissions in Pakistan through Nonlinear Autoregressive Distributed Lag (NARDL) model. Pakistan annual data are used and all variables are initially checked on their stationarity by the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests to ensure that all the variables are not integrated of order two, I (2) since NARDL can only be applied when the variables are a combination of I (0) and I (1). Having verified the order of integration, the study uses the NARDL model presented by Shin, Yu and Greenwood-Nimmo (2014) to reveal potential asymmetric impacts of financial development (FD) on CO_2 emissions. The NARDL approach disaggregates the independent variables especially financial development into positive shocks (FD +) and negative shocks (FD -), which enables the model to test whether the growth and decline in FD have different effects on emissions. This decomposition is performed by partial sum processes and this makes the model better than the linear ARDL in cases where the relationship may be nonlinear.

3.2. Model Specification

$$CO_2 = f(FD, FDI, GDP, GDP^2)$$

Where,
CO_2= Carbon Emission
FD= Financial Development
FDI= Foreign Direct Investment
GDP= Gross Domestic Product
GDP^2= (Gross Domestic Product)^2
Following is the model specification,

$$CO2_t = \phi_1 + \phi_2 FD_t - \phi_3 FD_t + \phi_4 FDI_t + \phi_5 GDP_t + \phi_6 GDP2_t \mu_t \quad (1)$$

Standard of the theory undertakes in above model, ϕ shows the coefficients of variables. The equation term of the model are generated below given:

$$\Delta CO2_t = \alpha_0 + \sum_{i=1}^{l} a_{1i} \Delta FD_{t-1} + \alpha_0 - \sum_{i=1}^{l} a_{1i} \Delta FD_{t-1} + \sum_{i=1}^{p} \alpha_{2i} \Delta FDI_{t-i} + \sum_{i=1}^{q} \alpha_{3i} \Delta GDP_{t-i} + \sum_{i=1}^{q} \alpha_{4i} \Delta GDP2_{t-i} + \phi\, CO2_{t-1} + \phi_2 FD_{t-2} - \phi_2 FD_{t-2} \quad (2)$$
$$\phi_3 FDI_{t-3} + \phi_4 GDP_{t-4} + \phi_5 GDP2_{t-5} + \mu_t$$

Data Table 1:

Sr. No	Variable Name	Abbreviation	Proxy	Data Sources
1	Carbon Emission	CO_2	Carbon dioxide (CO2) total	WDI
2	Foreign Direct Investment	FDI	Foreign net inflow (& of GDP)	WDI

3	Economic Growth	GDP	GDP (constant 2015 US$)	WDI
4	Economic Growth	GDP^2	GDP (constant 2015 US$)	WDI
5	Financial Development	FD	Financial development Index	IMF

4. Results and Discussions

The descriptive statistics provide an overview of the main characteristics of the variables used in the analysis. The results show that CO_2 emissions have an average value of 157.63, with a minimum of 70.47 and a maximum of 260.77, indicating substantial variation in environmental pressure over the sample period. The standard deviation (57.36) confirms high dispersion around the mean. The skewness value (0.079) suggests that CO_2 emissions are nearly symmetrically distributed, while the kurtosis value (1.89) indicates a flatter-than-normal distribution. The Jarque Bera probability (0.525) shows that CO_2 emissions are normally distributed. Financial development (FD) shows a relatively stable mean of 0.075, with low variability (standard deviation of 0.009), indicating that the financial sector changed slowly over time. The skewness value (0.81) suggests a moderate positive skew, meaning that higher values occur less frequently. With a kurtosis of 3.69 and a Jarque Bera probability of 0.193, the FD variable does not significantly deviate from normality. Foreign direct investment (FDI) displays a mean of 0.94, ranging from 0.31 to 3.04, showing considerable fluctuations in foreign capital inflows. The relatively high standard deviation (0.75) confirms this volatility. The skewness value (1.85) indicates a strong positive skew, meaning a few very high FDI values pull the distribution to the right. The kurtosis (5.16) shows a highly peaked distribution with heavy tails.

The Jarque Bera probability (0.000069) confirms that FDI is not normally distributed, most likely due to these extreme values. GDP (economic growth in absolute value) has a mean of 2.8×10^{11}, with a minimum of 1.63×10^{11} and a maximum of 4.13×10^{11}, reflecting Pakistan's gradual economic expansion over time. The standard deviation is relatively high (7.89×10^{10}), indicating significant growth variability. Skewness (0.18) suggests slight right skewness, while kurtosis (1.82) indicates a flatter-than-normal distribution. The Jarque–Bera probability (0.45) suggests no major deviation from normality. GDP^2, used to test the Environmental Kuznets Curve (EKC), has a mean of 523,896 and shows moderate variation (standard deviation of 75,091). Skewness and kurtosis values close to zero indicate a nearly normal distribution. The Jarque–Bera probability (0.49) confirms that the GDP^2 term is normally distributed. Overall, the descriptive statistics indicate that most variables follow a fairly normal distribution except FDI, which shows significant skewness and kurtosis. The variability is highest in the economic indicators (GDP and CO_2), while financial development remains relatively stable over the sample period. This information provides a useful foundation for the subsequent econometric analysis, particularly in understanding the behavior, distributional properties, and dynamic range of the variables.

Table 2: Descriptive Statistics

	CO_2	FD	FDI	GDP	GDP2
Mean	157.6305	0.075072	0.938997	2.80E+11	523895.7
Median	144.9923	0.075000	0.695308	2.65E+11	514662.0
Maximum	260.7671	0.101000	3.035719	4.13E+11	642656.0
Minimum	70.46979	0.062000	0.309595	1.63E+11	403177.6
Std. Dev.	57.35726	0.009223	0.750938	7.89E+10	75091.84
Skewness	0.079738	0.818879	1.850010	0.183391	0.011607
Kurtosis	1.899004	3.687434	5.167837	1.821473	1.828764
Jarque-Bera	1.289193	3.286270	19.15590	1.586933	1.429512
Probability	0.524874	0.193373	0.000069	0.452274	0.489311

The correlation matrix presents the linear relationship among the variables. The results indicate that CO_2 emissions are powerfully and positively linked with GDP (0.9611) and GDP^2 (0.9657). This suggests that as Pakistan's economic activity increases, CO_2 emissions also rise substantially. The strong correlation between CO_2 and GDP^2 also supports the inclusion of the quadratic term to test the Environmental Kuznets Curve (EKC) hypothesis. The correlation between CO_2 and financial development (0.1671) is positive but weak, implying that improvements in the financial sector have only a small direct association with environmental.

However, CO_2 has a weak negative bond with FDI (-0.1591), suggesting that higher foreign investment might slightly help reduce CO_2 emissions, possibly through cleaner technologies or efficiency improvements. Financial development (FD) displays a strong positive correlation with FDI (0.7995), representing that a extra developed financial sector is strongly linked with attracting higher levels of foreign investment. This is consistent with economic theory; as well-functioning financial markets reduce uncertainty for foreign investors. FD also shows very weak positive correlations with GDP (0.0958) and GDP^2 (0.1023), suggesting limited direct interaction with GDP. Foreign direct investment has a weak negative correlation with GDP (-0.2583) and GDP^2 (-0.2364). This indicates that FDI inflows slightly decline as GDP increases, possibly due to structural or policy issues where domestic economic growth does not fully align with foreign investment trends. FDI also shows a moderate but negative relationship with CO_2 emissions, implying that foreign investment may have a marginally positive environmental role, consistent with the "pollution halo hypothesis." Lastly, GDP and GDP^2 are almost perfectly correlated (0.9979), which is expected since GDP^2 is a mathematical transformation of GDP. Both variables also show strong positive correlations with CO_2 emissions, reflecting that economic expansion in Pakistan has historically been associated with higher pollution levels. Overall, the correlation matrix shows strong linkages between growth indicators and CO_2 emissions, while financial development and FDI display weaker and mixed associations with the environment and growth.

Table 3: Correlation Matrix

	CO_2	FD	FDI	GDP	GDP2
CO_2	1				
FD	0.1671	1			
FDI	0.1591	0.7995	1		
GDP	0.9611	0.0958	-0.2583	1	
GDP^2	0.9657	0.1023	-0.2364	0.9979	1

The Augmented Dickey Fuller and Phillips Perron tests were applied to inspect the stationarity properties of the indicator CO_2 emissions, financial development (FD), foreign direct investment (FDI), GDP, and GDP^2. The results specify that all variables are non-stationary at level, but they become stationary after first differencing.

Table 4: United Root Test

	ADF		PP	
	Level	1st Difference	Level	1st Difference
CO_2	-0.915460	-6.009723	-0.938275	-5.560175
	(0.7637)	(0.0001)	(0.7518)	(0.0002)
FD	-1.816634	-3.464348	-1.970459	-3.481359
	(0.3638)	(0.0189)	(0.2669)	(0.0182)
FDI	-2.581835	-3.107856	-1.997388	-3.107856
	(0.1109)	(0.0400)	(0.2859)	(0.0400)
GDP	0.657986	-4.571954	1.393400	-4.703172
	(0.9884)	(0.0015)	(0.9983)	(0.0011)
GDP^2	-0.305302	-4.314482	-0.299009	-4.373136
	(0.9104)	(0.0028)	(0.9114)	(0.0025)

The ARDL Bounds Cointegration Test was used to find out whether there is a long-run relationship between CO_2 emissions and its explanatory variables (financial development, FDI, GDP and GDP^2). The F-statistic is 4.60 and there are four regressors in the model (k = 4). In order to determine the cointegration, the F-statistic is compared to the Pesaran et al. (2001) critical bounds. The lower boundary (I0) and upper boundary (I1) at the 5% significance level are equal to 2.86 and 4.01 respectively. This establishes the fact that there is a stable long-run cointegration between the variables. The F-statistic exceeds the upper bound at the 2.5% level and is very near the upper bound at the 1% level even at more stringent levels of significance, like 2.5% (I1 = 4.49) and 1% (I1 = 5.06).

Table 5: Bound Test Result

Test Statistic	Value	k
F-statistic	4.60	4
Significance	I0 Bound	I1 Bound
10%	2.46	3.53
5%	2.87	4.02

2.5%	3.26	4.48
1%	3.75	5.07

The short-run NARDL estimates indicate significant asymmetric impacts of financial development as well as the influence of FDI, GDP, and GDP^2 in explaining the CO_2. The positive shock of FD positively affects and significantly the CO_2 emissions, with a coefficient of 3.12 (p = 0.0221). This implies that in the short run, CO_2 emission rises with the advancement of financial development, which implies that financial growth could initially sustain activities like industrial investment or credit growth, which increase environmental pressure. Conversely, the negative shock in the financial development is strongly and significantly negative. It means that the decrease in FD has a drastic impact on CO_2 in the short time. The high asymmetry between D(FD) + and D(FD)- indicates that the environment is more sensitive to the shrinkage of the financial sector than to its growth. The coefficient of foreign direct investment (D(LFDI)) is insignificant (0.0139) which means that the short-run variations in FDI have no significant effect on CO_2 emission. This implies that short term belongings of FDI inflows on the CO_2 are minimal, perhaps because of the slow pace of foreign technology absorption or the long-term investment project. The GDP has a positive and large effect on the CO_2 with a coefficient of 3.33 (p = 0.0108). This proves that the short run environmental degradation is directly proportional to the increase in economic activity because of energy consumption, industrial production and consumption. The negative value of the squared GDP ($D(GDP^2)$) is significant, indicating that the impact of economic growth on CO_2 is not linear. This helps in the first phase of the Environmental Kuznets Curve (EKC) which up to a certain point, growth in GDP^2 begins to diminish the emissions, even in short term. Lastly, the error-corrected term (CointEq (−1)) is a negative value with a value of great importance (coefficient = -0.7656, p = 0.0008). This shows that the rate of adaptation is high to long-run equilibrium. The current ratio of correcting the previous period of disequilibrium is close to 76.5 percent in a year, which is fast convergence to the long-run relationship.

Table 6: NARDL short run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FD)+	3.120628	3.065007	1.018147	0.0221
D(FD)-	-32.54994	10.86016	-2.997187	0.0081
D(LFDI)	0.013900	0.052061	0.266994	0.7925
D(LGDP)	3.330029	1.171880	2.841614	0.0108
$D(GDP^2)$	-0.523909	0.201374	-2.601672	0.0432
CointEq(-1)	-0.765562	0.190861	-4.011087	0.0008

The long-run NARDL estimates indicate the existence of considerable asymmetric impacts of financial development, as well as, significant long-run correlations among CO_2 emissions, foreign direct investment, and economic growth. The coefficient of the positive part of financial development (FD+) is 4.076 and statistically significant (p = 0.0409). This shows that in the long term, financial development increases result in higher CO_2 emissions. This finding suggests that financial growth, in terms of the availability of more credit, financing of investments, and development of the industrial sector, leads to an increase in the environmental degradation with time. The observation is consistent with the hypothesis of the scale effect, according to which financial development triggers economic activities, which are energy-intensive. On the other hand, the negative aspect of financial development (FD−) has a substantial negative impact on CO_2 emission with the coefficient of -3.427 (p = 0.0069). This implies that emissions are significantly reduced or contracted in the long run when financial development is reduced or contracted. The imbalance between FD+ and FD- proves that the environmental reaction to the changes in the financial sector is different according to the direction of the shock. Notably, financial contraction is more beneficial to the environment than the harm caused by financial expansion, which favors the asymmetric NARDL framework. The coefficient of FDI is insignificant (0.018) (p = 0.7909) and the effect of FDI on the CO_2 emission is not significant in the long term. This may mean that foreign investment does not radically change the environmental performance of Pakistan, perhaps because of the prevalence of investment in non-green sectors or poor environmental compliance systems.

This finding does not substantially confirm the pollution haven or the pollution halo hypothesis. The coefficient of Economic growth (LGDP) is positive and significant (4.349, p = 0.0046), indicating that in the long-run, higher CO_2 are caused by higher GDP. This means that long term growth path of Pakistan is still based on energy consuming activities and this is an indication of low development of clean production technologies. The GDP^2 is negative and

significant (−0.350802, p = 0.0312) indicating that the correlation between CO_2 emissions and economic growth is nonlinear. The positive LGDP and negative GDP^2 show that there is the (EKC) in the long-run. At first, the economic growth causes the rise in emissions, but beyond some point, the growth causes the environmental benefits, presumably because of the changes in the structure, cleaner technologies, and the rise of environmental consciousness.

Table 7: NARDL Long Run Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFD+	4.076260	4.166818	0.978267	0.0409
LFD-	-3.427628	1.114833	-3.074567	0.0069
LFDI	0.018156	0.067456	0.269162	0.7909
LGDP	4.349786	1.343833	3.236851	0.0046
$LGDP^2$	-0.350802	0.222359	-1.577638	0.0312
C	-103.657101	32.764396	-3.163712	0.0054

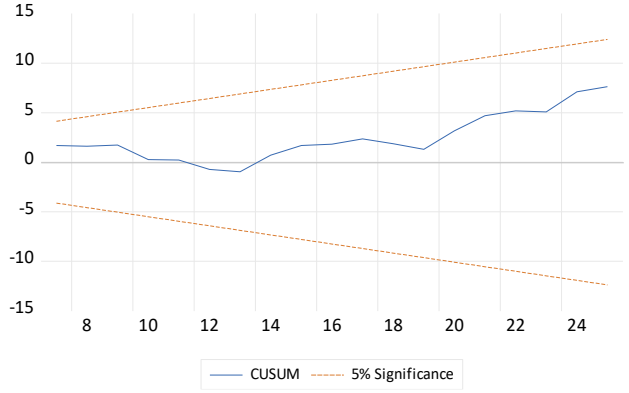
The diagnostic statistics show that the NARDL model is statistically reliable, well-specified and does not have any significant econometric issues. The value of R^2 of 0.9709 and the Adjusted R^2 of 0.9628 indicate that the independent variables used in the model accounted for about 96-97 percent of the variation in CO_2 emissions. This implies that the explanatory power is high and implies that the model fits the data very well. The F-statistic (120.3365) is very significant, which shows that the entire model is significantly significant. This proves that the regressors, in combination, have significant overall impact on CO_2 emissions. The statistic of Durbin-Watson (1.98) is near to the desired value (2) and this means that there is no issue of autocorrelation in the residuals. This makes the error terms of the model independent of time, a requirement of the validity of the regression estimates. The heteroscedasticity test (1.2783, 0.3160) indicates an insignificant value, which means that the model is not affected by heteroscedasticity. This implies that the variance of the residuals is fixed, which proves the accuracy of the standard errors and t-statistics. The Jarque-Braun (JB) test (0.5814, p = 0.7477) shows that the residual values follow a normal distribution, which is a significant assumption in testing hypotheses and estimating confidence intervals. The LM test of serial correlation (2.9834, p = 0.0792) is also not significant at the 5% level, which is another indication that the model is not affected by the serial correlation. This strengthens the validity and strength of the estimated coefficients. Lastly, the Ramsey RESET test (3.3162, p = 0.6412) is not significant statistically, which indicates that the model is well-specified without any omitted variable bias and misspecification of functional form.

Table 8: Diagnostic Results

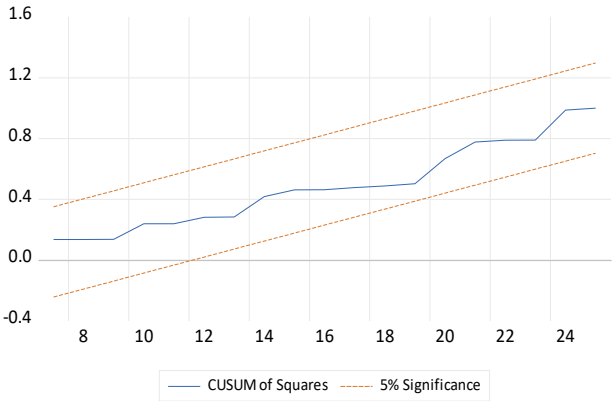
R^2	0.9709	DW (1.98)
Adj R^2	0.9628	F-Stat (120.3365)
Hetro Test	1.2783	(0.3160)
JB Test	0.5814	(0.7477)
LM Test	2.9834	(0.0792)
Ramsey Reset Test	3.3162	(0.6412)

Stability tests show that our model data and results or stable at 5% significant levels.

Figure 2: CUSUM



CUSUMQ



5. Concluding Remarks

The empirical results prove the presence of a long-run relationship between CO_2 emissions, financial development, FDI and economic growth in Pakistan. The asymmetric impacts of FD are as follows: positive shocks raise emissions, whereas negative shocks cause a substantial decrease in emissions. GDP grows the emissions, and GDP^2 is the support of the Environmental Kuznets Curve, which shows that the relationship is not linear. FDI is not significant in the short and long term implying low environmental spillover effects. The diagnostic tests ensure that NARDL model is well-specified and reliable. In general, the development in Pakistan is still carbon-intensive, and it needs powerful green financial reforms and cleaner growth policies. Financial development is a positive contributor to CO_2 emission and this is why the policy makers ought to green the financial sector by incorporating environmental standards in the financial flows. Pakistan ought to increase the green credit policies, motivate banks to fund renewable energy projects, and deter lending to polluting industries by increasing the risk weight or imposing environmental taxes. Enhanced sustainable finance systems, green bonds and incentivizing sustainable investments will make sure that financial development promotes low-carbon growth and not emission growth.

The fact that FDI has a positive effect on CO_2 indicates that there is pollution haven effect where foreign companies move the pollution-intensive sectors to Pakistan. Hence, the government needs to strengthen environmental policies on foreign investors. The policies should compel foreign companies to embrace clean production technologies, impose stringent environmental impact assessment (EIA) and provide incentives to only environmentally friendly FDI like renewable energy investments, electric mobility or green manufacturing. It is essential to change the quantity-based to quality-based FDI. As the economic growth raises the level of emissions in Pakistan, the policymakers need to redesign the growth policies to be environmentally friendly. These are the promotion of energy-efficient industrial processes, modernization of the manufacturing system in Pakistan, the development of urban public transport, and the promotion of technological innovation that will not be dependent on fossil fuel. To decouple the relationship between growth and emissions, a growth strategy, which is consistent with sustainable development goals (SDGs), is required. The fact that the coefficient of GDP^2 is positive means that Pakistan is not at the turning point of EKC; at higher growth rates, the level of emissions is still increasing. This requires a transition to green structural change, focusing on the growth of renewable energy, the policies of the circular economy, the price of carbon, and the decarburization of high-emitting industries. In the absence of this change, the growth of Pakistan will continue to be unsustainable in the environment.

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