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Exploring the Role of Government Expenditure and Fintech in Environmental Quality: Evidence from Pakistan

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ABSTRACT

The goal of achieving lower carbon emissions has recently become a hotly debated topic, and various studies have empirically assessed the repercussion of different economic variables on environment. This study examines the aftermath of GDP, government expenditure (GOE), FDI, and Fintech on CO2 in Pakistan from 1995 to 2023 by adopting the NARDL technique. The NARDL findings revealed that in positive shocks, GOE played a beneficial role in minimizing CO2 emissions, yet in negative shocks, GOE enhanced pollution levels in Pakistan. Moreover, FDI and GDP enhance environmental degradation, while Fintech mitigates CO2 emissions. These findings provide valuable insights for policy making. These findings also suggest that Pakistan should focus on reallocating government expenditures to green investments.

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1. Introduction

At the COP26 summit in Glasgow, countries worldwide were urged to set rigorous emissions reduction goals. Moreover, the UN sustainable development goals highlighted the UN's focus on environmental protection, economic growth, and social development. These goals also emphasize poverty eradication, social equity, and climate protection (Abbasi, Kirikkaleli, & Altuntaş, 2022). GHGs are the root cause of natural disasters and environmental degradation. Energy use in power plants is a critical benefactor to CO_2 emissions. Scientists and ecological experts worldwide are struggling to combat harmful environmental damage by reducing CO_2 and balancing economic growth and ecological sustainability (Faheem, Farooq, et al., 2023; Nousheen, Farooq, & Faheem, 2024). The rising temperature due to CO_2 poses a grave threat to human and environmental health; desertification, pollution, and soil degradation are the repercussions of rising CO_2 levels. Moreover, CO_2 emissions are a significant obstacle to achieving sustainable development goals (Faheem, Nousheen, et al., 2023). Environmental degradation driven by human activities complicates the balance between GDP and environmental sustainability. Along with human activities, the concentration of GHGs is posing severe threats. To address these problems, policymakers and scientists around the world should collaborate (Faheem et al., 2024). In global CO_2 emissions, the share of Pakistan is 0.8%. However, Pakistan has taken strong measures to reduce this share, including enhanced renewable energy transition, enhancements in the public transportation system, large-scale tree plantation, urban housing reforms and utilization of eco-friendly technologies in industries (Farooq et al., 2024). The economics of coal and gas-fired electricity can significantly fluctuate the CO2. To combat the challenge of CO2 and multi-pollutant, an integrated approach is crucial. Developed countries are committed to net zero carbon by 2050 (Azam, Khan, & Ali, 2023). 70% surge in CO2 from 1990 to 2023 compelled the researchers to find the reasons; they found the four key areas of addressing CO2, including economic factors, social aspects, use of energy in economic activities and transitions towards technological advancement (Alsedrah, 2024).

The government plays a significant role in pollution reduction through government expenditures. Government expenditure influences the environment both in direct and indirect ways. It can affect the environment indirectly by affecting economic growth, which leads to environmental sustainability. Moreover, expansionary fiscal policies implemented by the government also affect the environment (Khan et al., 2022). Government expenditures may be helpful in reducing CO_2 by investing in ecological initiatives which lead to improvements in environmental health and directly reduce the CO_2 (Jin et al., 2022). Fiscal policy and monetary policy, side by side, are crucial tools for policy intervention. Fiscal policy manages the demand side of the economy; it works through government spending and taxation to boost environmental sustainability (Yuelan et al., 2022). Globally, policymakers and governments are paying attention to the ways to reduce CO_2 and save the planet. Countries are investing heavily in climate change initiatives such as trade, FDI and GOE. The interaction between GDP and environmental sustainability might be helpful for CO_2 reduction (Gillani & Abbas, 2023). The researchers have focused intensely on the bond between FDI and CO_2 over the past two decades. This relationship is mainly discovered from two different perspectives: the pollution hallo hypothesis and the pollution haven hypothesis. The first hypothesis examines the direct link between FDI and CO_2, while the latter claims that FDI may increase CO_2, which happens due to relax environmental regulations in the host country (Xie, Wang, & Cong, 2020). FDI affects CO_2 both negatively and positively; it is beneficial in enhancing economic growth as FDI is a gateway to advanced technologies and financial support. Moreover, FDI acts as a catalyst, transferring advanced technologies and creating job opportunities and managerial expertise to developing countries from advanced countries (Faheem, Farooq, et al., 2023). Nevertheless, FDI boosts the economic growth of the host country, but the country pays the environmental cost of this economic growth. However, it brings challenges due to the increasing demand for energy for economic activities and degrades environmental health; developing countries compromise on environmental sustainability to attract FDI and enhance GDP (Farooq, Faheem, & Nousheen, 2023a). From 1980 to 2011, the share of developing countries in CO_2 emission rise from 48% to 61% just because of relaxed environmental regulations, so it is very crucial to develop ways to maintain balance in economic growth and environmental health, reduction in CO2 emission is crucial for environmental sustainability (Xie, Wang, & Cong, 2020).

Growing energy consumption, higher CO_2 emissions and environmental degradation are the outcomes of transitioning agricultural economy to the industrial economy. Rising energy demand for economic activities intensity the CO_2, Moreover it is observed that developing countries initially ignore the environmental damage and prioritize economic growth over environmental health (Faheem, Farooq, et al., 2023). GDP and CO_2 association is a global phenomenon; numerous economic activities fuel CO_2 and lead to environmental destruction. Economic activities include widespread economic operations across various industries and sectors and resultantly increase energy consumption and cause CO_2 (Farooq et al., 2024). Since 1990 energy consumption for economic activities in developing countries has surpassed the developed countries. Developing countries are growing their energy consumption to fuel their industrial growth (Farooq, Faheem, & Nousheen, 2023b). Economic growth can lead to higher CO_2 until carbon efficiency exceeds the GDP level 60% fall in CO_2 emissions is projected by 2050, while, global GDP is projected to nearly tipple (Abbasi, Kirikkaleli, & Altuntaş, 2022). The world leaders are increasingly focusing on the solutions to climate change and reduction in CO_2. Fintech emerges as a powerful tool to promote environmental sustainability and lower CO_2 emissions (Guo & Yin, 2024). Fintech is crucial for environmental preservation; it drives a positive impact on environmental health by enhancing resource allocation. Moreover, it supports natural resource management and green innovation and boosts environmental efficiency (Xu et al., 2023). Digital finance promotes clean energy use, improves carbon productivity and finally leads to low-carbon economic growth. Fintech facilitates efficient capital allocation to eco-friendly initiatives by leveraging a digital platform that supports sustainable business practices (Guo & Yin, 2024).

Many researchers have found fintech as a powerful source to mitigate CO_2. It significantly reduces CO_2 by fostering a sustainable industrial framework. Moreover, fintech could bring transformative changes through technological advancements, which could influence CO_2 in both positive and complex ways (Jiang et al., 2024). Fintech is revolutionizing financial services in many ways, enhancing accessibility, transparency and efficiency; it significantly empower small investors and promote environmental health. Additionally, it paves the way for a balance between social inclusion, environmental health and economic growth through green financing (Alsedrah, 2024). Fintech has revolutionized economies by blending innovations with accessibilities; it has also boosted energy efficiency by driving green investments. Moreover, Fintech has played a significant role in achieving the goal of a green future by reducing pollution and cutting waste (Lu, Tian, & Ge, 2023). This study makes valuable contributions by evaluating the non-linear asymmetric association between GOE, FDI, Fintech, GDP, and environmental sustainability. It documents the dual repercussion of FDI on the environment, whether FDI enhances CO_2 emissions or reduces them. This research focuses on the impact of Fintech on environmental preservation. To my knowledge, no one has worked on this model. Numerous studies have used traditional techniques to examine these variables. In contrast, we use the advanced NARDL technique to determine the non-linear asymmetric relationship between these variables, which enables us to investigate both positive and negative shocks.

The remaining article is structured as following: "Literature review," Theoretical framework, the methodology, Results and discussion, "Conclusion and Future Recommendations respectively.

2. Literature Review

Oh (2023) documented the affinity between the energy price index, number of workers, industrial area, final energy consumption, fiscal expenditure for air quality, and CO_2 for Korea. The research's final outcomes disclosed that government expenditures' direct effect declined CO_2, while indirect effects enhanced CO_2 emissions. Gillani and Abbas (2023) identified the correlation between GDP, energy use, FDI, government expenditures, trade, and CO_2 for selected 41 Asian countries (1996 to 2020). The outcomes disseminated that trade controls CO_2; conversely, FDI, energy, and government expenditures accelerate CO_2. Yuelan et al. (2022) explored the connection between government expenditure, tax revenue, GDP, energy use, FDI, and CO_2 for BRI countries. The FMOLS results revealed that all studied variables enhanced environmental pollution. For Ghana, Kwakwa (2022) documented the relationship between government final expenditure, industrialization, GDP, and CO_2 from 1971 to 2018. The outcomes of the ARDL confirmed that government expenditure decreased CO_2 emissions, while industrialization and GDP deteriorated environmental quality. From 2008 to 2018, Jin et al. (2022) asserted the correlation between green economic efficiency, government expenditure, GDP, FDI, FD and CO_2 for BRI countries. They declare that government expenditure, FDI, and GDP demolished environmental quality, while FD and green economic efficiency reduced environmental pollution. Khan et al. (2022) probed the correlation between nuclear energy, GDP, government expenditures, and CO_2 for the top 3 highest emitter countries from 1981 to 2016. The research's calculation of this paper declared that GDP square and nuclear energy cleaned the environment; GDP and government expenditures also damaged environmental quality.

Guo and Yin (2024) explored the tie between Fintech, FDI, green technology, ICT imports, and CO_2 for China employing the NARDL model. The outcomes uncovered that FDI deteriorated environmental quality. In positive shocks, Fintech and green technology reduced CO_2; conversely, in adverse shocks, they enhanced CO_2. Meanwhile, green energy reacted to the opposite of them. Jiang et al. (2024) probed the bond between TNR, Fintech, green ICT, and CO_2 in China from 2000 to 2021 utilizing the QARDL model. They found that Fintech and green ICT boosted environmental quality; conversely, natural resources damaged environmental health. Alsedrah (2024) probed the relationship between Fintech, GF, and CO_2 for 8 rich countries adopting the MMQR approach. The findings disclosed that green finance and fintech curb CO_2. Oh (2023) documented the affinity between the energy price index, number of workers, industrial area, final energy consumption, fiscal expenditure for air quality, and CO_2 for Korea. The research's final outcomes disclosed that government expenditures' direct effect declined CO_2, while indirect effects enhanced CO_2 emissions. Gillani and Abbas (2023) identified the correlation between GDP, energy use, FDI, government expenditures, trade, and CO_2 for selected 41 Asian countries from 1996 to 2020. The findings disseminated that trade controls CO_2; conversely, FDI, energy, and government expenditures accelerate CO_2. Kakar et al. (2024) employed the PMG model to investigate the relationship between INDS, Fintech, FD, trade openness, and CO_2 for 39 Asian countries from 1995 to 2022. The final calculations of the research exhibited that green fintech and trade openness lessened CO_2, while industrialization damaged environmental quality. Liu et al. (2024) employed the PGM model to govern the interconnection between Fintech, green finance, institutional performance, digital governance, and CO_2 emissions for BRI countries. The research's observed findings revealed that all studied variables stimulated environment.

Using the NARDL, Li et al. (2024) identified the connection between Fintech, TNRR, economic performance, and CO_2 in China. They found that Fintech improves the environment in positive shocks, while in negative shocks, Fintech harms the environmental quality; meanwhile, economic performance and natural resources stimulate environment in negative shocks, and inversely, in positive shocks, they decline ecological quality. Cheng, Qian and Wang (2024) governed the bond between green finance, Fintech, green technological innovation, population, economic growth, FD, and CO_2 emission for 30 Chinese provinces from 2011 to 2020. They confirmed that green finance and Fintech lessen CO_2. From 1990 to 2020, Li et al. (2024) found the interconnection between green energy, Fintech, natural resources, GDP, and CO_2 emissions for BRI countries. The outcomes disclosed that green energy and Fintech enhanced environmental quality while GDP and natural resources deteriorated. The tie between natural resources, Fintech, financial inclusion, renewable energy, and CO_2 during 2000 to 2019 for Central Asian economies was documented by Jie et al. (2024). The verifiable findings demonstrated that Fintech and natural in negative shocks enhanced environmental pollution, while positive shocks reduced CO_2. Financial inclusion positive shocks degrade the environment, while negative support environmental preservation. Firdousi, Afzal and Amir (2023) documented the interconnection between GDP, consumer price index, FDI, and CO_2 for MSCI 26 countries from 2011 to 2021. They confirmed that the consumer price index, FDI, and Fintech clean the environment; Conversely, GDP destroyed it. Adopting CS-ARDL, Lu, Tian and Ge (2023), for BRICS countries, identified the tie between environmental regulation, Fintech, CO_2 emissions and natural resources. They revealed that natural resources worsen environmental quality, while fintech and environmental regulations purify it. For BRICS, Udeagha and Ngepah (2023) identified a favorable correlation between green finance, Fintech, energy innovation, and environmental sustainability from 2000 to 2018, adopting the CS-ARDL model. Xu et al. (2023) explored the correlation between green finance, urbanization, industrial structure, environmental regulations, and CO_2 in China from 2011 to 2020. The paper's verifiable outcomes showed that Fintechh, urbanization, and government intervention accelerated environmental quality, while the industrial structure and environmental regulation lessened environmental quality. Tao et al. (2022) scrutinized the affinity between export, gross capital formation, GDP, Fintech, and CO_2 emissions from a global perspective. The paper's final findings uncovered that Fintech and export improve environmental quality while GDP and gross capital formation degrade it.

For Pakistan, Farooq et al. (2024) underscored the connection between GDP, tourism, globalization, and CO_2 from 1989 to 2022, adopting the ARDL model. They disseminated that all studied variables damaged the environment. Faheem, Farooq, et al. (2023) found the favorable bond between GDP and CO_2 for Pakistan, adopting an ARDL model during 2005 to 2021. Farooq, Faheem and Nousheen (2023b) explored the connection between GDP, TNRR, urbanization, and CO_2 for Pakistan utilizing the ARDL model. The final calculations revealed that GDP and urbanization damaged environmental quality; conversely, natural resources purified environmental quality. From 1990 to 2018, for Turkey, Abbasi, Kirikkaleli and Altuntaş (2022) adopted the NARDL model to explore the connection between FDI, CO_2 emissions, and GDP. The research confirmed that positive shocks enhanced environmental pollution, while adverse shocks of GDP cleaned the environment, and FDI deteriorated ecological quality. For Pakistan, Ali et al. (2021) explored the connection between GDP, energy use, and CO_2 from 1971 to 2014 utilizing the ARDL model. The results confirmed that, Surprisingly, GDP cleaned the environment, while energy and fossil fuels destroyed it. Lu (2018) asserted the association between GDP, FD, CO_2 and ICT in 12 Asian countries. The research's verifiable outcomes disseminated that FD and ICT improved environmental quality while GDP demolished it. Faheem et al. (2024) identified the attachment between FDI, FD, GDP, and CO_2 for Pakistan adopting ARDL, covering the years 1987 to 2022. The research uncovered that FD purified the environment, while GDP and FDI demolished it. Farooq, Faheem and Nousheen (2023b) identified the correlation between economic policy, FDI, URBN, and CO_2 from 1995 to 2021. The final calculation revealed that all studied variables accelerated CO_2 in Pakistan. Faheem, Farooq, et al. (2023) in Pakistan asserted the association between FIN, FDI, GDP, trade, and CO_2 utilizing the ARDL model. The outcomes confirmed that FDI and GDP deteriorated environmental quality while trade cleaned it.Lee and Zhao (2023) asserted the correlation between population GDP, human capital, FDI, and CO_2 for 96 countries, adopting an FMM model. They found that population and GDP demolished environmental quality, while human capital, FDI, and urbanization cleaned it. Abid et al. (2022) for G-8 countries probed the affiliation between technological innovation, FDI, GDP, and CO_2 utilizing an FMOLS approach. The final calculation of the paper divulge that FDI, urban population, and technological innovation decreased CO_2, while GDP and energy destroyed ecosystem. For emerging nations, Xie, Wang and Cong (2020) identified the tie between population, technology, FDI, trade, and CO_2 emissions. The calculation revealed that all studied variables damaged the environmental quality. Sreenu (2022) documented the bond between FDI, inflation rate, GOE, HC, financial services development, crude oil price, and exports of goods and services employing ARDL and NARDL model for India covering the years 1990 to 2020. They found that GDP demolished the environmental quality, while FDI in positive shocks cleaned the environment; conversely in negative shocks it exacerbated CO2, while crude oil prices reacted opposite of FDI. The interrelatedness between GDP, FDI, population, technological level, industrial structure, urbanization, and CO2 during the years 1995 to 2010 China was probed by Zhang and Zhou (2016). They finally conclude that FDI enhanced CO2.

3. Theoretical Framework

Copeland and Taylor (1994) presented the pollution heaven hypothesis, claims that FDI magnify the CO_2 levels. The developing countries compromise on environmental quality to attract FDI and enhance GDP with lax environmental regulations. Grossman and Krueger (1991) proposed the EKC hypothesis, which claims that GDP and environmental health show an inverted U-shaped relationship. At the initial stages of development, an increase in economic growth boost CO_2 emissions as industrialization and energy consumption increase. Moreover, as development grows, CO_2 emissions peak, reflecting a trade-off between GDP and CO_2. After reaching a certain point, environmental degradation starts declining. This happens due to high-income levels, the transition towards renewable energy, and strict environmental regulations. Porter and Linde (1995) proposed the pollution Halo hypothesis, states that FDI and CO_2 are negatively connected. Due to technological advancements, FDI brings innovations and leads to a decline in CO_2.

4. Data and Methodology

This study examines the impact of government expenditures, foreign direct investment, Fintech, and GDP on CO_2 emissions in Pakistan from 1995 to 2023. The Data used in this study have been collected from WDI.

Table 1

Variable	**Proxy**	**Notation**	**Source**
Carbon dioxide	CO_2 emissions (kt)	CO_2	WDI
Government Expendoture	General government's final consumption expenditure (current US$)	GOE	WDI
Foreign direct investment,	net inflows (% of GDP)	FDI	WDI
Fintech	Medium and high-tech manufacturing value added (% manufacturing value added).	FNT	WDI
GDP	GDP growth (annual %)	GDP	WDI

The present study utilized the NARDL technique and develops a conceptual design to examine the impact of GOE, FDI, Fintech, and GDP on CO_2 emissions in Pakistan. Mathematically model is as follows.

$$CO2 = f\,(GOE, GDP, FNT, FDI) \qquad \text{(i)}$$

In econometrics, the equation looks like this:

$$CO_{2t} = \partial_1 + \partial_2 GOE_t + \partial_3 GDP_t + \partial_4 FNT_t + \partial_5 FDI_t + \mu_t \qquad \text{(ii)}$$

$$\Delta CO_{2t} = \partial_0 + \sum_{j=1}^{J1} \partial_{1i} \Delta CO_{2t-1} + \sum_{j=0}^{J2} \partial_{2i} \Delta GOE_{t-i} + \sum_{j=0}^{J3} \partial_{3i} \Delta GDP_{t-i} + \sum_{j=0}^{J4} \partial_{4i} FNT_{t-i} + \sum_{j=0}^{J5} \partial_5 \Delta FDI_{t-i}$$
$$+ \varepsilon_0 CO_{2t-1} + \varepsilon_1 GOE_{t-1} + \varepsilon_2 GDP_{t-1} + \varepsilon_3 FNT_{t-1} + \varepsilon_4 FDI_{t-1} + \mu_t \qquad \text{(iii)}$$

In Equation (iii) ∂1 to ∂5 represents the intercepts and slopes of GOE, FDI, FTN and GDP.ECT equation

$$\Delta CO_{2t} = \partial_1 + \sum_{i=1}^{j} \partial_{1i} \Delta CO_{2t-1} + \sum_{i=0}^{j1} \partial_{2i} \Delta GOE_{t-i} + \sum_{i=0}^{j2} \partial_{3i} \Delta GDP_{t-i} + \sum_{i=0}^{j3} \partial_{4i} \Delta FNT_{t-i} + \sum_{i=0}^{j4} \partial_{5i} \Delta FDI_{t-i} + \lambda ECT - 1 + vt_t$$

(iv)

The NARDL Model is given below

$$\Delta CO_{2t} = \partial_1 + \sum_{j=1}^{J} \partial_{2i} \Delta CO_{2t-1} + \sum_{j=0}^{J1} \partial_{3i} \Delta GOE^{+}{}_{t-i} + \sum_{j=0}^{J2} \partial_{4i} \Delta GOE^{-}{}_{t-i} + \sum_{j=0}^{J3} \partial_{5i} \Delta GDP_{t-i} + \sum_{j=0}^{J4} \partial_{6i} FNT_{t-i} + \sum_{j=0}^{J5} \partial_{7i} \Delta FDI_{t-i} + \varepsilon_1 CO_{2t-1} + \varepsilon_2 GOE^{+}{}_{t-1} + \varepsilon_3 GOE^{-}{}_{t-1} + \varepsilon_4 GDP_{t-1} + \varepsilon_5 FNT_{t-1} + \varepsilon_6 FDI_{t-1} + \mu_t$$

(v)

∂1, is an intercept ∂2, ∂3, ∂4, ∂5, ∂6, and ∂7 are measures of independent variables μ indicates residual. Here, "ï" and "t" represent the cross-section and time-frequency. Before proceeding to NARDL equations we applied a bound test for determining the co integration of variables.

5. Analysis and Discussions of Results

Table 2 represents the descriptive statistics. The findings reveal that CO_2 emissions have a mean value of –0.2502, a maximum -0.04469, minimum -0.40027, and a standard deviation of 0.1121. The mean value of GOE is 23.57, with a maximum value of 24.39 and a minimum of 22.59, thus having a standard deviation of 0.617, the highest deviation among the used variables. Similarly, FDI has a mean value of -0.1199, a maximum of -1.172, and a standard deviation of 0.610. To confirm the irregular path of the data set, we employed the Jarque and Bera normality test.

Table 2: Descriptive Statistics and Correlation

	CO_2	GOE	FDI	GDP	FNT
Mean	-0.2502	23.57961	-0.19967	1.35232	3.186465
Median	-0.25763	23.78653	-0.20627	1.44929	3.133537
Maximum	-0.04464	24.39533	1.110448	2.058123	3.377408
Minimum	-0.40278	22.59878	-1.17249	0.014293	3.046689
Std. Dev.	0.112187	0.617968	0.610789	0.480051	0.094644
Skewness	0.141698	-0.2432	0.550905	-0.91191	0.949156
Kurtosis	1.804756	1.602164	2.717041	3.699581	3.097695
Jarque-Bera	1.697535	2.464348	1.455808	4.292666	4.064771
Probability	0.427942	0.291658	0.48292	0.116912	0.131023
Sum	-6.75544	636.6494	-5.391	36.51264	86.03455
Sum Sq. Dev.	0.327234	9.928994	9.69963	5.991672	0.232897
CO_2	1				
GOE	0.91371	1			
FDI	0.051266	-0.17137	1		
GDP	0.261367	0.205813	-0.07503	1	
FNT	-0.67709	-0.78598	0.228179	-0.17226	1

After descriptive statistics, this study examined the stationarity of variables. All variables are found stationary either at I(0) or I(I). GOE and Fintech are stationary at levels in ADF and PP tests, while CO_2 FDI and GDP are stationary at the first difference in ADF and PP.

Table 3: Unit Root Tests

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	-0.029	-4.737***	-0.016	-4.717***
GOE	-7.181***	-6.651***	-6.941***	-31.821***
FDI	-2.606	-3.725***	-2.073	-3.725***
FNT	-3.154**	-2.046***	-3.500**	-5.549***
GDP	-0.494	-6.743***	-0.488	-4.746***

In the table 4 bound test findings confirms the long run association among the variables as computed F-statistics is higher than all upper bound values.

Table 4: Bound Test

F-statistics	K	Range	Critical values	
			I(0) bound	**I(1) bound**
5.35	4	10%	2.26	3.35
		5%	2.62	3.79
		1%	3.41	4.68

Table 5 displays NARDL's long-run and short-run results. The non-linear asymmetric association between GOE and CO_2 emissions is mainly examined in this study. For the decrease or increase of decomposed variables, the long-run results display the computed coefficients of positive and negative sums. The long-run results of NARDL show that positive and negative turns of GOE are -0.194 and 0.025, individually. The coefficients of rising (decreasing) GOE reveal that a 1% rise in GOE will reduce 0.194% CO_2 emissions. This relationship is significant at a 1% level, while a 1% reduction in GOE will boost CO_2 by 0.025%. In negative shock GOE and CO_2 relationship is found to be significant at a 5% level. Our findings of negative association between GOE and CO_2 are alike with Oh (2023) for Korea, while the positive association between GOE and CO_2 emissions is similar to Gillani and Abbas (2023) for 41 Asian countries. The positive coefficient of FDI in relation to CO_2 emissions indicates that a 1 unit upsurge in FDI will enhance environmental damage by 0.041%. Faheem et al. (2024) for Pakistan and Xie, Wang and Cong (2020) for emerging countries have found the same results. This relationship is significant at a 5% level. The link between Fintech and CO_2 is found to be significantly negative, revealing that a 1 unit hike in Fintech will decrease CO_2 by 0.379 eventually. The negative relationship shows the favorable influence of Fintech on environmental protection. Finally, the favorable link between GDP and CO_2 emissions is significant at a 5% level. These outcomes show the devastating impact of GDP on environmental conservation. The outcomes of analysis imply that a 1 unit growth in GDP will enhance CO_2 emissions by 0.068%.

Table 5: Long and Short Run Estimates

Variables	Coefficient	[S.E]	{T-st}
Long Run			
GOE^{pos}	-0.194***	[0.03]	{-5.57}
GOE^{neg}	0.025**	[0.01]	{2.16}
FDI	0.041**	[0.02]	{2.04}
FNT	-0.379	[0.16]	{-2.34}
GDP	0.068*	[0.03]	{1.91}
Short Run			
$D(GOE)^{pos}$	0.120***	[0.03]	{3.08}
$D(GOE)^{NEG}$	0.379**	[0.16]	{2.34}
D(FDI)	0.025**	[0.01]	{2.16}
D(FNT)	-0.159	[0.15]	{-1.05}
D(GDP)	0.026	[0.01]	{1.68}
CointEq(-1)	- 0.620***	[0.16]	{-3.84}

Note: ** & *** denotes significance level at 5% & 1%, respectively

The table 6 shows the diagnostic results and finding reveals that model is free from major problems and stable in the long run.

Table 6: Diagnostic Tests

R^2	0.932
Adj R^2	0.905
D-W	2.31
LM	0.858(0.443)
Jarque-Bera	0.115(0.997)
Hetero	0.875(0.544)
Ramsey	2.487(0.116)

5.1. Stability Graphs

Figure 1: CUSUM

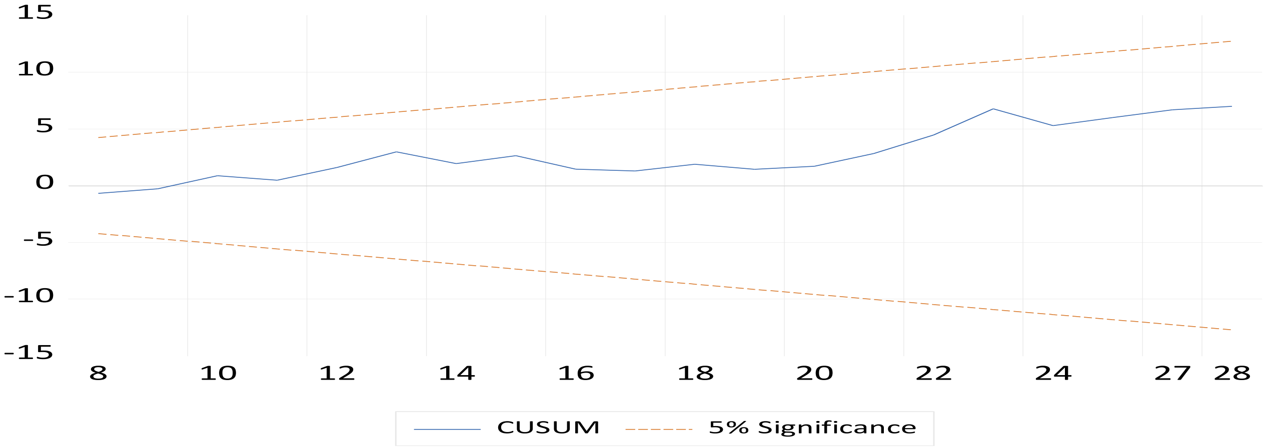
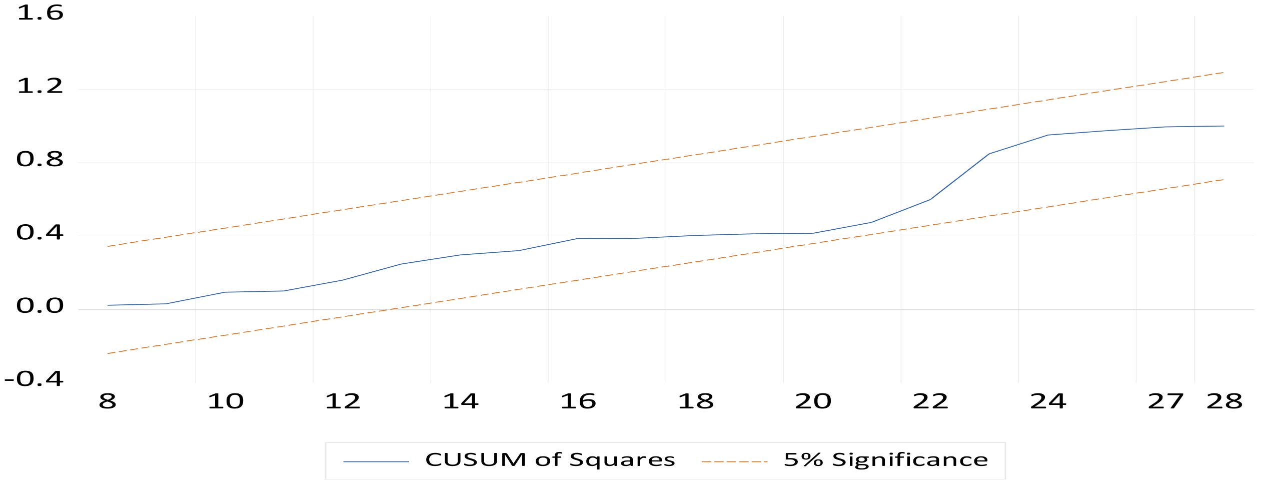


Figure 2



6. Concluding Remarks

The reverberation of government expenditure, FDI, Fintech, and GDP on CO_2 has been examined for Pakistan from 1995 to 2023. The study employed NARDL to determine the long-run non-linear tie between studied variables. The long-run estimates of NARDL revealed that Positive shocks of government expenditures played a beneficial role in mitigating CO_2, while negative shocks explicated harmful impacts on environment. FDI and GDP have been found dangerous for environmental sustainability as both tend to enhance CO_2 in Pakistan. The results confirmed the pollution heaven hypothesis. Finally, the results revealed a negative association between Fintech and CO_2 emissions. Fintech played a favorable role in minimizing CO_2 in the long run. In regard to the findings, this study has suggested some policies that can help the country combat the battle of environmental degradation. This study offers valuable suggestions for achieving a sustainable environment. The government of Pakistan should promote green government expenditure by reallocating the expenditures. GOE should focus on the practice of sustainable energy sources, and enhance the public transportation system which may contribute to reducing environmental degradation. To tackle the problem associated with GDP, the government of Pakistan should implement strict environmental rules and regulations. Moreover, the government should focus on public-private partnerships, which may be fruitful in reallocating resources. The government should develop a green taxation system.

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