SPCRD GLOBAL PUBLISHING Sustainable Solutions
READS Review of Economics and Development Studies
Journal homepage: http://reads.spcrd.org ISSN (Print): 2519-9692 ISSN (Online): 2519-9706

Can Financial Development Help in Raising Sustainable Economic Growth and Reduce Environmental Pollution in Pakistan? Evidence from Non Linear ARDL Model

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ARTICLE DETAILS

History:
Accepted 25 October 2021
Available Online December 2021

Keywords:
Sustainable Economic Growth, Environmental Pollution, Financial Development, NARDL, KOF Index

JEL Classification:
Q01, P27

DOI: 10.47067/reads.v7i4.406

ABSTRACT

It is a global challenge to reduce environmental pollution and enhance sustainable economic growth. This study explores the role of financial development as an instrument in reducing environmental pollution and enhancing sustainable economic development in Pakistan for the period 1980-2020. The Non-linear Autoregressive Distributed Lag (NARDL) econometrics technique has been utilized to find the association between environmental pollution, economic growth, and financial development. The results show that positive shocks of financial development increase economic growth and reduce environmental pollution. While the negative shocks of financial development increase both economic growth and environmental pollution. Globalization has negative impact on economic growth and the use of energy increases economic growth and environmental pollution. The study suggests that the State Bank of Pakistan and other financial institutions should formulate and implement soft loan policies to induce the private investors to use low carbon emission technologies.

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1. Introduction

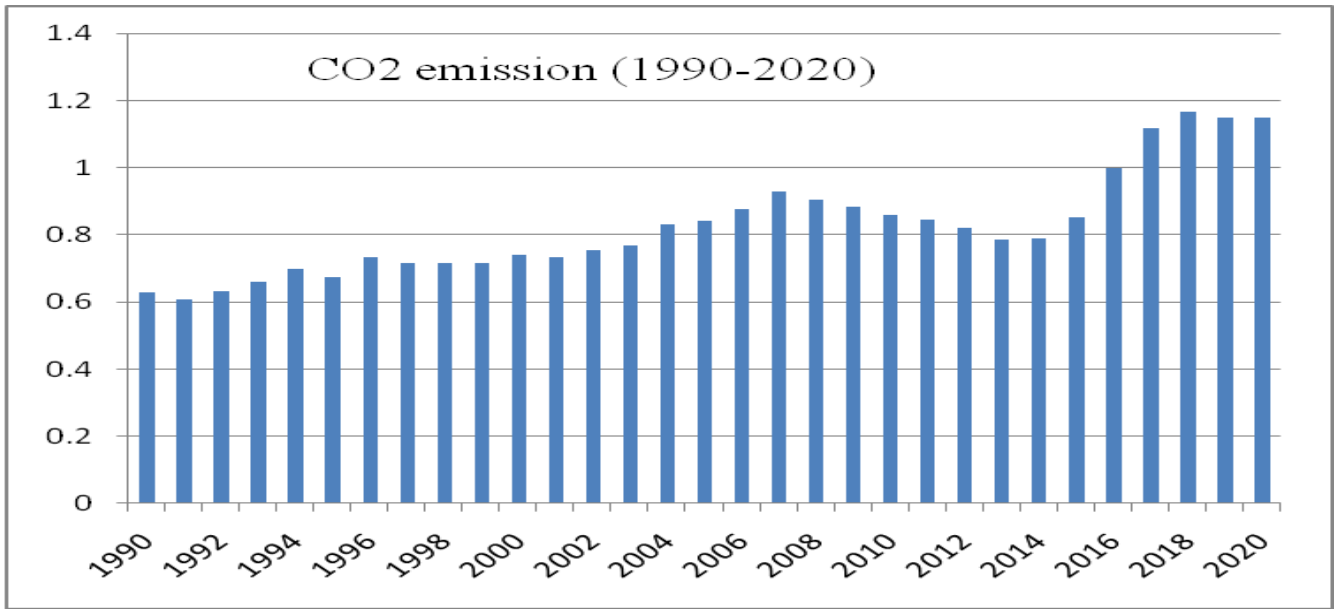
Now a days it is a big challenge for policymakers to control environmental pollution and increase sustainable economic development. Several decades ago, the policymakers only focus on economic growth and ignore environmental changes. Fossil fuels have been ruthlessly consumed to boost economic growth which greatly increased the carbon dioxide (CO_2) emission in the atmosphere.

Nowadays, the most challenging issue faced by the world is global warming. According to National Oceanic and Atmospheric Administration, NOAA (2020), the average temperature increased by 0.13^{o}F per decade since 1980, but in 1981 it increased more than twice (0.32^{o}F). World Meteorological Organization, WMO (2020) declared the last decade as the warmest decade on record. A continuous increase in global temperature is responsible for climate change which cause floods, heat, droughts, fires, tropical cyclones, and storms. These incidents pose a threat to global economic growth. Swissre (2021) predicated if no mitigation is taken place and global temperature could increase by more than 3^{o}C then global GDP may shrink by 18% in the next 30 years. Asian economies would be severely affected by the loss of GDP.

It is a quite difficult task to reduce CO_2 emissions because industry, agriculture and transport sectors in most of the countries realize heavily dependent upon gas, coal, and oil consumption. These sectors provide employment and produce goods which increase economic growth (Khan *et al.*, 2020). Since a decrease in fossil energy consumption may adversely affect economic growth. So, the developing countries are reluctant to reduce fossil fuel consumption and a continuous increase in environmental pollution may be observed over time.

The industrial, agricultural and transportation sectors are closely associated with financial system and efficient financial system promotes economic growth (Jiang *et al.* 2019). Before the 1970s most of the developing countries were financially repressed due to various discriminatory taxes and policies like high reserve requirements, credit controls, low interest rates, and high inflation rates that had exerted a bad impact on the financing decisions. After the 1990s most of the countries of the world have introduced financial reforms which has increased the desire to achieve rapid pace of economic development. This increases the demand and consumption of energy that are responsible for climate change.

This study tries to access the way in which environmental pollution can be reduced and how economic growth can be enhanced by using Pakistan's financial development indicators. Pakistan is among top ten countries which are mostly affected by climate change in the last 20 years as it faced 152 extreme weather events during 1999-2018 and lost 0.53 % per unit GDP and economic loss worth US$3792.52 million (Global climate risk Index, 2021). In the last decade Pakistan's per capita CO_2 emission has increased 3% annually (WDI, 2021). Figure 1 shows the details of CO_2 emission metric ton per capita for the period 1990-2020. In the last five years, an average of 1.07 metric tons of CO_2 emission have increased which is an alarming situation for Pakistan.



After the 1990 financial reforms, the financial sector of Pakistan has been developed. According to the Bloomberg (2016) report, Pakistan's financial sector have grown rapidly and have shown promising signs of persistent increase in economic growth. In Pakistan, the financial sector plays an important role in industrial development, a well-organized baking system, agricultural development, government policies, exchange rate stability, political stability, well-founded education sector, monetary and fiscal policy, etc. These factors helped in enhancing economic growth through attracting foreign direct investment.

There is mixed evidence regarding the relationship betweeen financial development on CO_2 emissions in Pakistan. Some studies argued that financial development has increased CO_2 emission in Pakistan (Khan, *et al.* 2020; Majeed *et al.*, 2020; Ahmad *et al.*, 2020; Raza & Shah, 2018; Shahzad *et al.,* 2017; Siddique, 2017; Javid & Sharif, 2016; Muhammad & Ghulam, 2013; Zhang, 2011). These studies argue that the financial development help the consumers to get loans easily who prefer to buy refrigerators, motorbikes, cars, air-conditioners that emit CO_2 emissions. On the other hand, the foreign and domestic investors invest in those projects which have less transaction cost without caring about CO_2 emissions which ultimately enhance pollution.

While on the other side, a few studies have pointed out that financial development has decreased CO_2 emission in Pakistan (Godil, *et al.,* 2020; Ali, *et al.*, 2015; Shahzad, *et al.,* 2014). These studies argued that the developed financial sector attracts most of the investment from developed countries and also developed countries prefer to invest in those projects which are environment friendly. After 9/11 Pakistan have received a lot of foreign direct investment, loans, and aid from developed countries. It helped the country to invest in high-tech projects which resulted in low carbon emissions. This is the reason that Pakistan is declared as a low CO_2 emission country in the region. Apart from this Pakistan have imposed an environment friendly policy to reduce environmental pollution.

Now-a-days each country of the world has a desire to achieve sustainable economic development without environmental loss. This study is an attempt to have a deep insight into the role of financial development in achieving sustainable economic growth without environmental loss in Pakistan. The study will stress on the aspect that does an increase in the financial development depict an asymmetric relationship with economic growth and carbon emissions? If not what is the optimal composition of financial development with economic growth and carbon emissions?

The significance of the study stems from the fact that it analyzes the role of financial development as the key tool to achieve sustainable economic development and diminish the environmental losses in Pakistan. Furthermore, this study is not limiting itself from the previous studies conducted in Pakistan (Javid *et al*. 2016; Shahzad *et al.,* 2017; Raza & Shah, 2018; Chen*, et al*., 2019; Khan, *et al*. 2020) but it extends its application to asymmetric impacts on economic growth and environmental pollution. Not many studies are available on Pakistan economy in which non-linear analysis has been carried out to explore the nexus between financial development with sustainable economic growth and environmental pollution.

2. Review of Literature

This section reviews previous literature related to the nexus between financial development, economic growth, and environmental pollution. Several studies are available in literature that have examined the linear association between the financial development with economic growth and environmental pollution (see for example: Khan *et al*., 2020; Yang, 2019; Asteriou & Spanos, 2019; Bist, 2018; Cetin *et al*. 2018). There are only a few studies have pointed out that financial development also had a non-linear association with economic growth and carbon emissions (Chen *et al.* 2020; Nenbee & Danielle, 2021; Maneejuk & Yamaka, 2021; Shahbaz *et al.* 2017).

Shahbaz *et al.* (2017) investigated the asymmetric analysis between financial development and economic growth for the period 1960Q1 to 2015Q4 in India. The NARDL approach was used to find the causal relationship between the concerned variables. The results of the study reveal that any positive shocks in financial development decreases economic growth while the negative shock increases economic growth.

Qamruzzaman and Jianguo (2018) explored the asymmetric association between banking sector development, financial innovation, and economic growth in selected Asian countries during 1974Q1-2016Q4. The study concluded that in the long run, Pakistan had a significant and positive asymmetric association between economic growth and domestic credit to the financial sector.

Chen *et al.* (2020) analyzed the asymmetric impact of the financial development index on economic growth during 1972-2017 in Kenya. The results of the study show that positive partial shock of financial development index was insignificant in the long run while the negative partial shock of financial development index was statistically significant which increases economic growth.

Aigheyisi and Edore (2019) examined the asymmetric effect of broad money supply on economic growth in Nigeria from 1981 to 2016. The results show that broad money supply had a statistically insignificant positive effect on economic growth while the negative change in broad money supply is statistically significant and had positive effect on economic growth in the long run..

The literature show mixed evidence between asymmetric impact of financial development on environmental pollution. Ling *et al.* (2021) pointed out that the positive shocks in financial development significantly increase carbon emissions while the negative shocks insignificantly increase carbon emissions. In Pakistan Majeed *et al.* (2020) examined the asymmetric impact of financial development on carbon emissions from 1972 to 2018. The NARDL approach validated that positive shocks in financial development are statistically insignificant which increase carbon emissions while the negative shocks in financial development is statistically significant which decrease carbon emissions.

Ahmad *et al.* (2018) tried to find the asymmetric effect of financial development on carbon

emission from 1980 to 2014 using NARDL approach. The results show that in the long run positive shocks of financial development increases carbon emissions significantly while negative shocks have an insignificant impact on carbon emission.

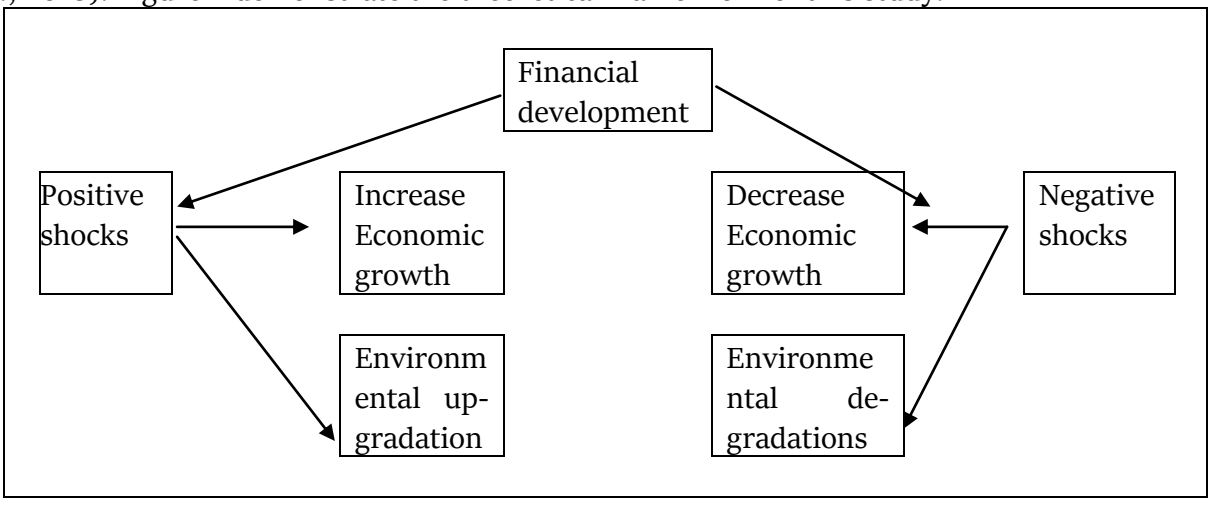
Ahmad *et al.* (2020) constructed financial development index (FD) by incorporating money supply, liquid liabilities and domestic credit to the banking sector during 1996-2018 for Pakistan. The study concluded that financial development had an asymmetric effect on carbon emission. The positive and negative shocks of financial development both decrease the carbon emissions in Pakistan.

Some studies linked the financial development variables with ecological footprints. Ahmed *et al.* (2021) linked financial development with ecological footprints during 1971-2016 in Japan. The study analyzed the asymmetric relationship between financial development and ecological footprints and concluded that an increase and decrease in financial development lead to an increase the ecological footprints in the long run. Omoke *et al.* (2020) investigated the asymmetric effect of the financial development index on ecological footprints of non-carbon and carbon in Nigeria during 1971-2014. The study concluded that a positive increase in the financial development index statistically and significantly decline carbon ecological footprints while a negative decline in the financial development index statistically and significantly increase the carbon ecological footprints.

The review of literature mentioned above that not many studies are available on the asymmetric relationship between financial development, economic growth and environmental pollution. Furthermore, the results related to the above mentioned relationship between the variables are not clear which calls for the need to deeply examine the asymmetric association between financial development, economic growth and environmental pollution. This study uses NARDL approach for estimating the relationship between the variables in the context of Pakistan economy.

3. Conceptual framework and Methodology

Financial sector is considered as an important segment of Pakistan's economy which faces both positive and negative shocks frequently. Therefore, these shocks cannot be ignored to capture their impact on economic growth and environmental pollution. This study is conducted in the light of research work by Shin *et al.* (2014) in which they decomposed the variable in the positive and negative partial sums. Usually, the positive shocks in financial development increase economic growth and environmental up-gradation while the negative shocks decrease economic growth and environmental degradations (Chen *et al.*,2020; Ling *et al.*, 2021; Aigheyisi & Edore, 2019; Karasoy *et al.,* 2019; Ahmad *et al.*, 2018). Figure 2 demonstrate the theoretical frame work of this study.



In the present study financial development is measured in terms of domestic credit to banks (DCB). Economic growth is measured in terms of gross domestic product (GDP) and environmental pollution is measured by CO_2 emissions in metric tons. The data has been collected from WDI for the period 1980-2020. The description of the variables is presented in Table 1.

Table 1 Description of the Variables

Symbols	Indicator	Units	Source
GDP	Gross domestic product	Constant LCU	WDI-2021
CO2	CO2 emissions	metric tons per capita	WDI-2021
DCB	Domestic credit to Banks	% of GDP	WDI-2021
EDU	Primary education enrollment	% of gross	WDI-2021
KOF	Globalization	Index	Swiss economic institute
EU	Energy use	kg of oil equivalent per capita	WDI-2021
URPOP	Urban population	% of total population	WDI-2021

This study has derived the empirical model from the Cobb-Douglas production function and carbon emissions written as;

$$GDP = f(FD_{i,t}^{\alpha_1}, EDU_{i,t}^{\alpha_2}, KOF_{i,t}^{\alpha_3}, EU_{i,t}^{\alpha_4}, URPOP_{i,t}^{\alpha_5}) \quad (1)$$

$$CO2 = f(FD_{i,t}^{\beta_1}, EDU_{i,t}^{\beta_2}, KOF_{i,t}^{\beta_3}, EU_{i,t}^{\beta_4}, URPOP_{i,t}^{\beta_5}) \quad (2)$$

Where FD means financial development which is measured in terms of credit to banks (DCB), EDU means primary education, KOF shows the globalization, EU means energy use, URPOP stands for urban population while GDP and CO_2 show economic growth and carbon emissions. In the light of equation 1 and 2 the following econometric models are formulated:

$$LNGDP = \alpha_0 + \alpha_1 LNFD_{i,t} + \alpha_2 LNEDU_{i,t} + \alpha_3 LNKOF_{i,t} + \alpha_4 LNEU_{i,t} + \alpha_5 LNURPOP_{i,t} + \varepsilon_t \quad (3)$$

$$LNCO2 = \beta_0 + \beta_1 LNFD_{i,t} + \beta_2 LNEDU_{i,t} + \beta_3 LNKOF_{i,t} + \beta_4 LNEU_{i,t} + \beta_5 LNURPOP_{i,t} + \varepsilon_t \quad (4)$$

Model 3 and 4 have been applied to bring up the above mentioned relationship between variables in the context of Pakistan economy. These models seems to be inappropriate for Pakistan as it's financial development sector did not remain stable during 1980-2020 due to many ups and downs as shown in figure 3.

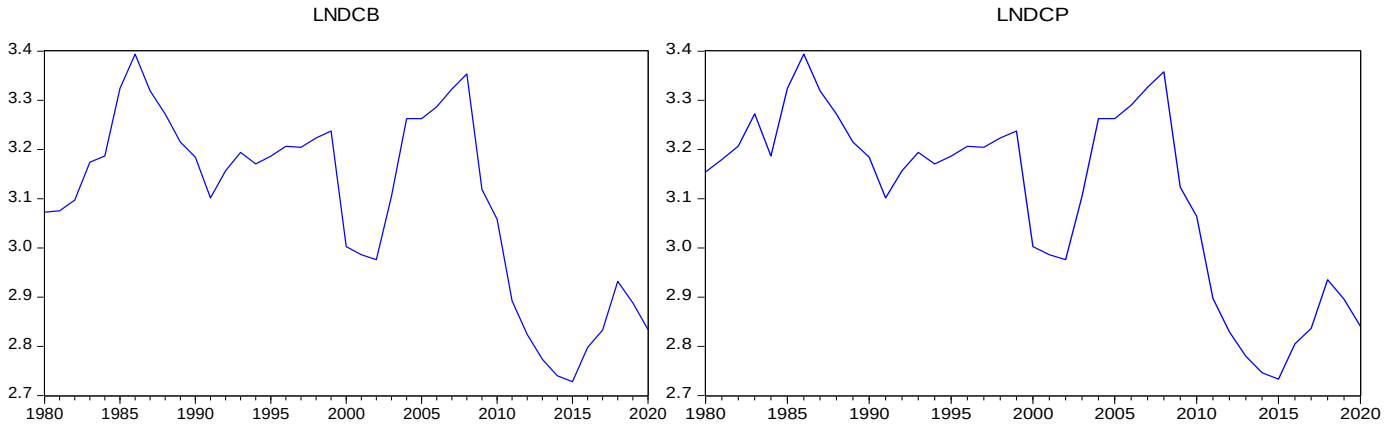


Figure 3 Graphs of financial development variables

The present study uses NARDL approach that is extended version of ARDL. The asymmetric relationship between financial development, economic growth and environmental pollution can be written as

$$LNGDP = \alpha_0 + \alpha_1^+ LNFD_{i,t}^+ + \alpha_1^+ LNFD_{i,t}^- + \alpha_2 LNEDU_{i,t} + \alpha_3 LNKOF_{i,t} + \alpha_4 LNEU_{i,t} + \alpha_5 LNURPOP_{i,t} + \varepsilon_t \quad (5)$$

$$LNCO2 = \beta_0 + \beta_1^+ LNFD_{i,t}^+ + \beta_1^+ LNFD_{i,t}^- + \beta_2 LNEDU_{i,t} + \beta_3 LNKOF_{i,t} + \beta_4 LNEU_{i,t} + \beta_5 LNURPOP_{i,t} + \varepsilon_t \quad (6)$$

The asymmetric effect of financial development is a combination of both positive change as $LNFD^+$ and negative changes as $LNFD^-$.

The positive and negative series of LNFD can be summarized in the partial sum process as follows:

$$LNFD^+ = \sum_{i=1}^{t} \Delta(LNFD)^+ = \sum_{i=1}^{t} \max(\Delta LNFD, 0) \quad \& \quad LNFD^- = \sum_{i=1}^{t} \Delta(LNFD)^- = \sum_{i=1}^{t} \min(\Delta LNFD, 0) \quad (7)$$

For the NARDL setting, the dynamic of the long run and short coefficients are incorporated in the equation as:

$$\Delta \boldsymbol{LNGDP} = \boldsymbol{\alpha_0} + \sum_{K=1}^{m} \boldsymbol{\alpha_1} \Delta(\boldsymbol{LNGDP})_{t-k} + \sum_{k=1}^{m} \boldsymbol{\alpha_{2k}^+} \Delta(\boldsymbol{LNFD})_{t-k}^+ + \sum_{k=1}^{m} \boldsymbol{\alpha_{2k}^-} \Delta(\boldsymbol{LNFD})_{t-k}^- + + \sum_{k=1}^{m} \boldsymbol{\alpha_{3k}} \Delta(\boldsymbol{LNEDU})_{t-k} + \sum_{k=1}^{m} \boldsymbol{\alpha_{4k}} \Delta(\boldsymbol{LNKOF})_{t-k} + \sum_{k=1}^{m} \boldsymbol{\alpha_{5k}} \Delta(\boldsymbol{LNEU})_{t-k} + \sum_{k=1}^{m} \boldsymbol{\alpha_{6k}} \Delta(\boldsymbol{LNURPOP})_{t-k} + \boldsymbol{\alpha_7}(\boldsymbol{LNGDP})_{t-1} + \boldsymbol{\alpha_{8k}^+}(\mathbf{LNFD})_{t-1}^+ + \boldsymbol{\alpha_{8k}^-}(\mathbf{LNFD})_{t-1}^- + \boldsymbol{\alpha_{9k}}(\boldsymbol{LNEDU})_{t-1} + \boldsymbol{\alpha_{10k}}(\boldsymbol{LNKOF})_{t-1} + \boldsymbol{\alpha_{11k}}(\boldsymbol{LNEU})_{t-1} + \boldsymbol{\alpha_{12k}}(\boldsymbol{LNURPOP})_{t-1} + \boldsymbol{\varepsilon_t} \quad \mathbf{(8)}$$

$$\Delta LNCO2 = \alpha_0 + \sum_{K=1}^{m} \alpha_1 \Delta(LNCO2)_{t-k} + \sum_{k=1}^{m} \beta_{2k}^+ \Delta(\mathrm{LNFD})_{t-k}^+ + \sum_{k=1}^{m} \beta_{2k}^- \Delta(\mathrm{LNFD})_{t-k}^- + + \sum_{k=1}^{m} \beta_{3k} \Delta(LNEDU)_{t-k} + \sum_{k=1}^{m} \beta_{4k} \Delta(LNKOF)_{t-k} + \sum_{k=1}^{m} \beta_{5k} \Delta(LNEU)_{t-k} + \sum_{k=1}^{m} \beta_{6k} \Delta(LNURPOP)_{t-k} + \beta_7(LNC02)_{t-1} + \beta_{8k}^+(\mathrm{LNFD})_{t-1}^+ + \beta_{8k}^-(\mathrm{LNFD})_{t-1}^- + \beta_{9k}(LNEDU)_{t-1} + \beta_{10k}(LNKOF)_{t-1} + \beta_{11k}(LNEU)_{t-1} + \beta_{12k}(LNURPOP)_{t-1} + \varepsilon_t \quad (9)$$

In equations 8 and 9, α_{2k}^{+}, α_{2k}^{-} andβ_{2k}^{+} , β_{2k}^{-}show the short term impact of LNFD on LNGDP and LNFD on LNCO2 respectively. After incorporating the Error Correction Term the short-run dynamics of the model are calculated below:

$$\Delta LNGDP = \alpha_0 + \sum_{K=1}^{m} \alpha_1 \Delta(LNGDP)_{t-k} + \sum_{k=1}^{m} \alpha_{2k}^{+} \Delta(LN\mathrm{FD})_{t-k}^{+} + \sum_{k=1}^{m} \alpha_{2k}^{-} \Delta(LN\mathrm{FD})_{t-k}^{-} + + \sum_{k=1}^{m} \alpha_{3k} \Delta(LNEDU)_{t-k} + \sum_{k=1}^{m} \alpha_{4k} \Delta(LNKOF)_{t-k} + \sum_{k=1}^{m} \alpha_{5k} \Delta(LNEU)_{t-k} + \sum_{k=1}^{m} \alpha_{6k} \Delta(LNURPOP)_{t-k} + \alpha_7 (LNGDP)_{t-1} + \alpha_{8k}^{+} (\mathrm{LNFD})_{t-1}^{+} + \alpha_{8k}^{-} (\mathrm{LNFD})_{t-1}^{-} + \alpha_{9k} (LNEDU)_{t-1} + \alpha_{10k} (LNKOF)_{t-1} + \alpha_{11k} (LNEU)_{t-1} + \alpha_{12k} (LNURPOP)_{t-1} + \vartheta_t ECT_{t-1} + \varepsilon_t \quad (10)$$

$$\Delta LNCO2 = \alpha_0 + \sum_{K=1}^{m} \alpha_1 \Delta(LNCO2)_{t-k} + \sum_{k=1}^{m} \alpha_{2k}^{+} \Delta(LN\mathrm{FD})_{t-k}^{+} + \sum_{k=1}^{m} \alpha_{2k}^{-} \Delta(LN\mathrm{FD})_{t-k}^{-} + + \sum_{k=1}^{m} \alpha_{3k} \Delta(LNEDU)_{t-k} + \sum_{k=1}^{m} \alpha_{4k} \Delta(LNKOF)_{t-k} + \sum_{k=1}^{m} \alpha_{5k} \Delta(LNEU)_{t-k} + \sum_{k=1}^{m} \alpha_{6k} \Delta(LNURPOP)_{t-k} + \alpha_7 (LNC02)_{t-1} + \alpha_{8k}^{+} (\mathrm{LNFD})_{t-1}^{+} + \alpha_{8k}^{-} (\mathrm{LNFD})_{t-1}^{-} + \alpha_{9k} (LNEDU)_{t-1} + \alpha_{10k} (LNKOF)_{t-1} + \alpha_{11k} (LNEU)_{t-1} + \alpha_{12k} (LNURPOP)_{t-1} + \vartheta_t ECT_{t-1} + \varepsilon_t \quad (11)$$

In these equation$\theta^{+} = \alpha_{8K}^{+}/\alpha_7$s and$\theta^{-} = \alpha_{8K}^{-}/\alpha_7$ are long-term coefficients of LNFD on LNGDP while$\rho^{+} = \beta_{8K}^{+}/\beta_7$ and $\rho^{-} = \beta_{8K}^{-}/\beta_7$ are the long term coefficients of LNFD on $LNCO_2$.The variables$\sum_{k=1}^{m} \alpha_{2k}^{+} \Delta(LN\mathrm{FD})_{t-k}^{+}$,$\sum_{k=1}^{m} \alpha_{2k}^{-} \Delta(LN\mathrm{FD})_{t-k}^{-}$,$\sum_{k=1}^{m} \beta_{2k}^{+} \Delta(LN\mathrm{FD})_{t-k}^{+}$, and $\sum_{k=1}^{m} \beta_{2k}^{-} \Delta(LN\mathrm{FD})_{t-k}^{-}$ are short run adjustment variables of LNFD on LNGDP and LNFD on LNCO2 respectively. While Δ shows the difference operators.. The implementation of equations 10-11 yields F-statistics bound value to test the null hypothesis with lower and upper critical values (Pesaran et al. 2001; Narayan, 2005; Omoke *et al*., 2021).

The long-run asymmetries of financial development are obtained by the Wald test. The long run asymmetries of LNFD on LNGDP and LNFD on CO_2 show that $\theta^{+} \neq \theta^{-}$ and$\rho^{+} \neq \rho^{-}$ respectively. Furthermore, the asymmetric cumulative multiplier effect on LNGDP for one percent change in $LNFD^{+}$and $LNFD^{-}$ is formulated as:

$$K_b^{+} = \sum_{k=1}^{m} \frac{\Delta LNGDP_{t+k}}{\Delta FD_{t-1}^{+}} \ , K_b^{-} = \sum_{k=1}^{m} \frac{\Delta LNGDP_{t+k}}{\Delta FD_{t-1}^{-}}$$

In the same way, the asymmetric cumulative multiplier effect of $LNCO_2$ for unit change in $LNFD^{+}$ and $LNFD^{-}$ is formulated as:

$$K_b^{+} = \sum_{k=1}^{m} \frac{\Delta LNCO2_{t+k}}{\Delta FD_{t-1}^{+}} \ , K_b^{-} = \sum_{k=1}^{m} \frac{\Delta LNCO2_{t+k}}{\Delta FD_{t-1}^{-}}$$

If $b \to \infty$ then $K_b^{+} \to \theta^{+}, K_b^{+} \to \rho^{+}$ and $K_b^{-} \to \theta^{-}, K_b^{-} \to \rho^{-}$ are the asymmetric long run coefficients.

4. Results and Discussion

Descriptive statistics are presented in Table 2. There is no pre condition of NARDL whether the series is I(0) or I(1).

Table 2 Descriptive statistics							
	LNCO2	LNGDP	LNDCB	LNEDU	LNEU	LNKOF	LNURPOP
Mean	-0.40	29.43	3.10	4.25	6.05	3.80	17.62
Median	-0.38	29.43	3.16	4.26	6.09	3.83	17.66
Maximum	-0.02	30.22	3.39	4.57	6.22	4.01	18.22
Minimum	-0.89	28.43	2.73	3.90	5.76	3.50	16.90
Std. Dev.	0.23	0.52	0.19	0.20	0.12	0.19	0.39
Skewness	-0.41	-0.19	-0.51	-0.10	-0.94	-0.39	-0.22
Kurtosis	2.35	1.97	2.15	1.83	2.75	1.64	1.86
Jarque-Bera	1.89	2.06	3.00	2.38	6.19	4.22	2.56
Probability	0.39	0.36	0.22	0.30	0.05	0.12	0.28
Observations	41	41	41	41	41	41	41

Note: *, **, *** show level of significance at 1%, 5% and 10% .

The financial sector of Pakistan shows fluctuations due to 1990 oil shocks, 9/11 incident in 2001, 2008 financial crises, and most recent Covd-19 also paralyzed the whole economy (Amjad *et al*. 2021). According to Perron (1990) in the presence of structural breaks in data the traditional unit rot test may be misleading. The present study uses Zivot and Andrews (2002) unit root test to confirm the order of integration. Table 3 shows the results of Zivot and Andrews unit roots and reports that all variables are stationary either I(0) or I(1). The result of the unit root test are reported in Table 3.

Table 3 Zivot and Andrews Unit root with Break test				
	Level		1st difference	
	t-statistic	year of break	t-statistic	year of break
LNCO2	-2.709	2014	-5.68*	2007
LNGDP	-7.72**	2003	-4.29***	1992
LNDCB	-4.56**	2008	-4.98*	2004
LNEU	-4.48**	1986	-6.99*	2007
LNEDU	1.90	2013	-8.60*	2011
LNURPOP	-1.62	2000	-7.04*	1998
LNKOF	-4.93**	1988	-7.18*	1989

Note: *, **, *** show level of significance at 1%, 5% and 10% .

All the variables are I(0) or I(1). Table 4 presents the results of the long-run co-integration test. The values of F- statistic are higher than upper bound test at all given significance levels which means long rum co-integration exists among the variables.

Table 4 *Bounds testing of Linear ARDL*			
Models	F-statistic	I(0) 10%	I(1) 10%
(LNGDP LNDCB^{+}, LNDCB^{-}, LNEDU, LNKOF, LNEU, LNURPOP)	4.61	2.12	3.23
(LNCO2 LNDCB^{+}, LNDCB^{-}, LNEDU, LNKOF, LNEU, LNURPOP)	4.48	1.75	2.87

The long run coefficients of NARDL are reported in Table 5. In model 1, the study captured the impact of domestic credit to banks (LNDCB) proxy of financial development on economic growth. LNDCB is decomposed into positive series $LNDCB^{+}$ and negative series $LNDCB^{-}$. A one percent increase in the $LNDCB^{+}$ significantly increases LNGDP on average of 0.29% respectively (Qamruzzaman & Jianguo, 2018). One percent decline in $LNDCB^{-}$ significantly increases LNGDP on average of 0.45% (Shahbaz *et al.,* 2017). In simple words, the positive and negative shocks of LNDCB both increase economic growth in Pakistan. The Wald test presented in table 6 indicates that the LNDCB has asymmetric behavior. In Pakistan after 1990 the privatization and liberalization of the banking sector improved the financial sector which helped in increasing economic growth.

In model 2 the LNDCB is used as a proxy of financial development which is decomposed into positive series as $LNDCB^{+}$ and negative series as $LNDCB^{-}$. One percent increase in LNDCB+ insignificantly reduces carbon emissions on average of 0.17% CO_2 emission. (Ahmad *et al*., 2020; Lahiani, 2020; Odugbesan & Adebayo, 2020; Omoke *et al.,* 2020). Similarly one percent decline in $LNDCB^{-}$ significantly increase on average carbon emission an average of 0.58% (Ahmad *et al*., 2021; Jakada *et al*., 2020; Karasoy *et al.,* 2019). It implies that positive shocks in LNDCB decline CO_2 emissions while the negative shocks of LNDCB increases CO_2 emissions in Pakistan. Therefore, the null hypothesis is rejected and it is concluded that financial development has asymmetric behavior of economic growth and CO_2 emissions. Figure 3 shows the dynamic multiplier effects of LNDCB.

In Pakistan, foreign aid and debts are the major sources which contribute in improving financial sector. Pakistan has received heavy doses of foreign aid from World Bank to control environmental pollution during 2014-2017. These loans increased the financial development in Pakistan and helped in raising the import of environment friendly technologies. Moreover, the improvement in financial development helped the private investors to expand their businesses through the use of modern technology in the production process.

Table 5 Long run coefficients of NARDL

	Model 1	Model 2
	LNGDP	LNCO2
Variable	ARDL(2, 2, 2, 1, 2, 2, 0)	ARDL(2, 2, 2, 2, 2, 2, 2)
$LNDCB^{+}$	0.29* (0.08)	-0.17 (0.17)
$LNDCB^{-}$	-0.45* (0.09)	-0.58* (0.14)
LNEDU	0.94* (0.26)	3.02* (0.46)
LNKOF	-0.88 (0.18)	-1.56* (0.48)
LNEU	1.33* (0.27)	2.46* (0.49)
LNURPOP	0.18 (0.22)	-1.28* (0.20)
C	17.28* (2.09)	

Note: * show level of significance at 1%, while standard errors are in parenthesis

Table 6 *Results of Wald Test*		
Variables	F-statistic(Prob.)	Decisions
LNDCB	23.51(0.000)	An asymmetric relationship exists between LNDCB and LNGDP
LNDCB	4.86(0.038)	An asymmetric relationship exists between LNDCB and LNCO2

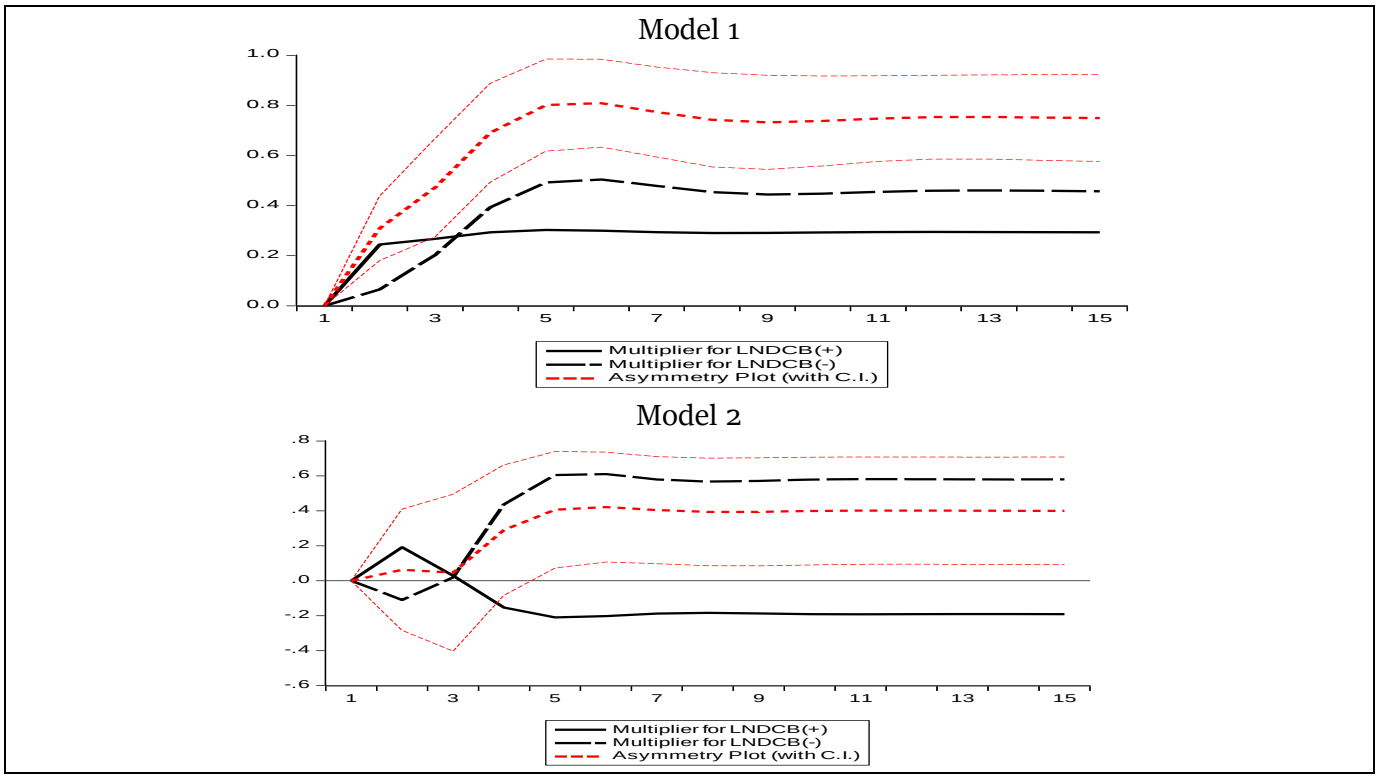


Figure 3 Dynamic multiplier effects

The other variables which are used in both models for finding the asymmetric behavior of the economic growth and carbon emissions include primary education (LNEDU), energy use (LNEU), globalization (KOF), and urban populations (LNURPOP). In model 1, primary education (LNEDU) significantly increases economic growth (Nenbee & Danielle, 2021; Maneejuk & Yamaka, 2021). Globalization inversely impacts economic growth (Shaheer & Butt, 2021). Energy use (LNEDU) positively impacts economic growth (Abbasi *et al.* 2021).

In model 2 primary education (LNEDU) has positive impact on carbon emissions. The people who have primary education niether care about environmental pollutions nor even prefer to use modern eco-friendly technologies. The globalization has negative impact on carbon emissions (Islam *et al.*, 2021; Sharif *et al.*, 2020; Bu *et al.*, 2016). It means that globalization is not harmful to environmental degradation in Pakistan. The trade liberalization after 1980 provided more opportunities to establish different industries in Pakistan which mostly use energy-efficient technologies and helped in declining carbon pollution. Energy use (LNEU) has positive impact on carbon emissions. Pakistan meets most of its energy requirements from fossil fuels which are considered as major contributor to carbon emissions.

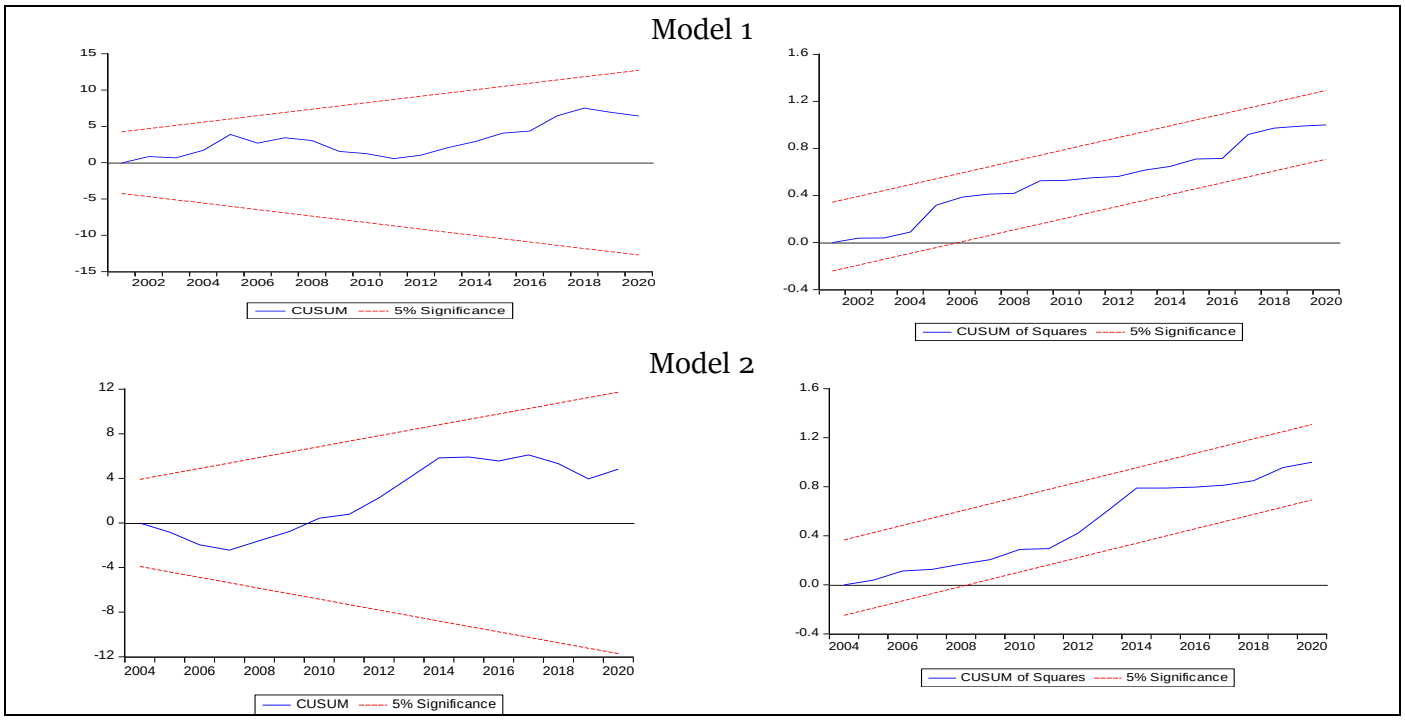
As far as short run analysis is concerned in both models, the values of error correction terms (ECM) are negative and significant which means a disequilibrium in the models converge towards the

equilibrium. In both the models values of error correction terms in both models are -0.58 and -0.71 respectively which means model 1, 58% and model 2, 71% converge to long run equilibrium in one period.

Table 7 short coefficient of NARDL		
	1(a)	2(a)
Variable	LNGDP	LNCO2
ECM	-0.58* (0.11)	-0.71* (0.15)
D(LNGDP(-1))	0.35** (0.17)	
D(LNCO2(-1))		0.19 (0.16)
$D(LNDCB^{+})$	0.25* (0.06)	0.19 (0.16)
$D(LNDCB^{+}(-1))$	-0.09 (0.06)	0.07 (0.16)
$D(LNDCB^{-})$	-0.06 (0.04)	0.11 (0.10)
$D(LNDCB^{-}(-1))$	0.11* (0.04)	0.35* (0.100
D(LNEU)	0.33** (0.14)	1.22* (0.33)
D(LNEU(-1))	-0.49** (0.19)	-0.70 (0.44)
D(LNKOF)	-0.41** (0.14)	-0.99** (0.38)
D(LNKOF(-1))	0.18 (0.11)	-0.12 (0.25)
D(LNEDU)	0.34** (0.12)	0.52*** (0.26)
D(LNEDU(-1))		-0.84** (0.34)
D(LNURPOP)	0.10 (0.14)	-9.44 (10.12)
D(LNURPOP(-1))		12.32 (13.82)

Note: *, **, *** show level of significance at 1%, 5% and 10% while standard errors are in parenthesis

Figure 4 presents the graphs of CUSUM and CUSUMSQ. The trend line lie in between the upper and lower boundary which means that both models are stable. Both the models also passed the diagnostic test.



5. Conclusion

This study explores the asymmetric relation between financial development, economic growth, and environmental pollution in Pakistan. For this purpose annual time series data has been used from 1980 to 2020. The bound test finds that financial development has a long-run relationship with economic growth (LNGDP) and environmental pollution ($LNCO_2$). The empirical findings of NARDL reveal that financial development exerts asymmetric long-run impact on LNGDP and $LNCO_2$ in both models. An increase or decrease in financial development significantly increase LNGDP (Qamruzzaman & Jianguo, 2018; Shahbaz *et al.,* 2017). Domestic credit to banks and the private sector at soft conditions increase investment which increases economic growth. While on the other hand, positive shocks in financial development decline CO_2 emissions and the negative shocks of financial development increase CO_2 emissions in Pakistan (Ahmad *et al.*, 2021; Ahmad *et al.*, 2020; Lahiani, 2020; Odugbesan & Adebayo, 2020; Omoke *et al.,* 2020; Jakada *et al.*, 2020; Karasoy *et al.,* 2019).

In Pakistan, foreign aid and debts are major sources to improve the financial sector. These loans exerts positive impact on financial development and increase investment through import of environment friendly technologies in Pakistan. Moreover, the improvement in financial development induces private investors to expand their scale of operations for earning more profits.

In summary, the financial institutions can play an important role to improve environment and achieve rapid economic growth in Pakistan. This study recommends that the State Banks of Pakistan and other international financial organizations should provide loans at zero-interest rate for inducing the private investors to use low carbon emission technologies. It will help to achieve rapid economic growth and reduce carbon emissions in Pakistan

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