



Revisiting the environmental impact of financial development on economic growth and carbon emissions: evidence from South Asian economies

Tayyaba Rani¹ · Muhammad Asif Amjad² · Nabila Asghar³ · Hafeez Ur Rehman⁴

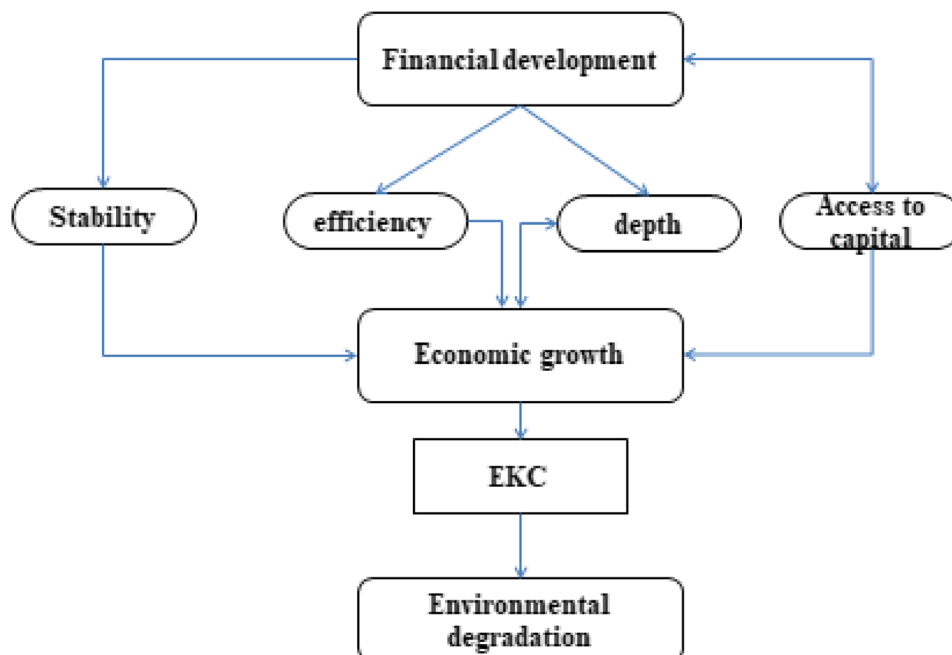
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Abstract

It is a global challenge to achieve sustainable economic growth by improving the environment. The present study discussed the role of the financial development sector in achieving sustainable economic growth and environmental quality in South Asian countries from 1990 to 2020 by controlling labour force participation, globalization, industrialization, and the education sector. A feasible generalized least squares (FGLS) panel data econometric technique has been used to check the relationship among the variables. The results show that financial development has a U-shaped relationship with carbon emissions and economic growth. Furthermore, labour force participation, industrialization, globalization, and educational school enrolment significantly increase CO₂ and economic growth. This study suggests that the governments of South Asian countries should take steps to increase economic growth. For this purpose, effective supervisory mechanisms of financial development through financial innovation, improving financial efficiency, maintaining financial stability, and reducing the environmental pollution.

Graphical abstract



Keywords Financial development · Economic growth · South Asian countries · Environmental degradation · Globalization

Introduction

The steadily increasing environmental deterioration of the world has made achieving the objective of sustainable development extremely difficult. It has become a major challenge for researchers and policymakers to achieve sustainable development by controlling environmental degradation. On one side, human activities increase economic growth, while, in return, it badly pollutes our atmosphere and cause global warming Rani et al., (2022). The ice and glaciers are melting rapidly due to climate change issues. The NOAA (2020) estimated that the average global temperature has increased by 0.13 °F since 1980, but it is expected to be doubled. In 2020, WMO (2020) acknowledged that the last decade had been the warmest. Keeping in view the importance of the most recent conference on climate change, COP 26, also pays special attention to climate change issues. At this conference, thousands of envoys and more than 130 heads of different countries met and set new targets to cope with climate change issues (Friedman, 2021, November 15).

The present study explores sustainable economic growth by protecting the environment through the financial development sector in South Asian countries. This study is based on the motivation for the first and third Sustainable Development Goals (SDG) under COP 26. The South Asian region is important because it is the home of 34% world's poorest population (Islam et al., 2021). Furthermore, this region is at the edge of the catastrophic effect of climate change (Germanwatch, 2021). Out of eight, five countries are included in the list of Germanwatch (2021) of most affected countries by the climate risk. The most vulnerable countries to climate change are India, Pakistan, Nepal, and Afghanistan.

The financial development sector is indispensable for any economy because most economic activities depend on it and it serves as the ventilator to all productive units, markets, and institutions that increase economic growth

(Usman & Hammar, 2021). The advanced financial system is a competitive and efficient measure to allocate savings, support trade, and helps in diversification. It also works for hedging the risk and allows for easier access to investment opportunities for economic growth. The financial development sector promotes economic growth because transportation, agriculture, and industrial sector are closely interconnected with the financial sector. These sectors are the major contributors to economic growth (Jiang et al., 2019). Several developing countries introduced major reforms after 1990 which have increased the economic growth in many countries. But oil shock of the 1990s, the 9/11 incident, the financial crisis in 2008, the Covid-19 pandemic, and the Russian-Ukrainian war have badly affected the financial sector. These shocks become hurdles in the way of economic growth of these countries which failed to handle these shocks properly (Rahman et al. 2020); on the other hand, it is pointed out that those countries that cope with these crises properly enjoyed economic growth (Ahmad et al. 2022).

To achieve sustainable growth, we cannot ignore the importance of a clean and neat environment. Due to rapid growth in the financial sector, the agriculture, industrial, and transportation sectors require more energy for work. Usually, most countries meet their energy requirements through fossil fuel consumption, thus emitting carbon dioxide (CO₂). Several studies indicate that the FD sector is base of environmental degradation (Khan et al., 2022; Jiang & Ma, 2019; Tahir et al., 2021). In some developed countries, the strong FD sector causes improvements in the environment (Shobande & Ogbeifun, 2022; Abid et al., 2022).

In South Asian regions, GDP per capita increases swiftly compared to the other lower-income countries. It is noted in Fig. 1 that all selected South Asian countries' GDP per capita is rising at a consistent speed. Sri Lanka and Bhutan are at the top with higher GDP per capita.

Furthermore, in this region, average CO₂ was recorded at 0.99 metric tons in 2020, which is higher than the other lower-income countries (WDI, 2022). Figure 2 shows the

Fig. 1 GDP Per capita in from 2000 to 2020

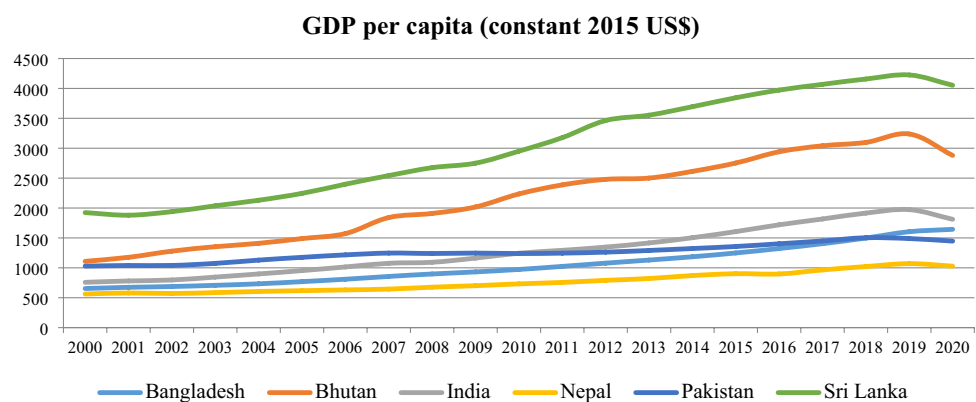
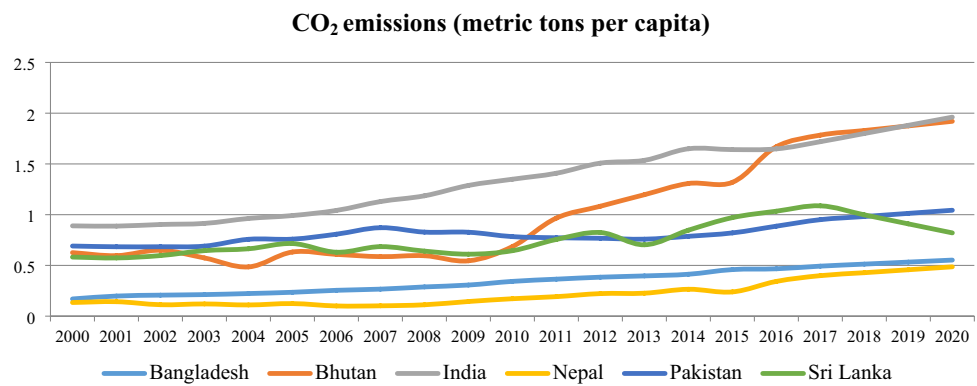


Fig. 2 CO₂ per capita from 1990 to 2020



CO₂ in selected South Asian countries from 2000 to 2020. It is observed that CO₂ is increasing consistently in all South Asian countries. India and Bhutan are with the highest carbon emissions. Due to the massive growth in carbon emissions, the average temperature rises in this region, causing many extreme events.

Previous studies have analysed the impact of financial development (FD) on a country's growth. But not many studies have explored the separate effects of FD on CO₂ and economic growth in South Asian economies. This brings up the need to check the relationship between them. The current study tries to fill the gap by using the nonlinear effect of FD on economic growth and CO₂ in South Asian countries. This study plays a significant role in achieving the sustainable development goals of South Asian countries. It endeavours to contribute to FD and further understanding of a sustainable environment. Therefore, the primary objective of this study is to examine the impact of nonlinear FD on economic growth and carbon emissions.

The rest of the study is organized as follows. The second section reviews both theoretical and empirical literature. The third section focuses on the methodology to be employed for analysis. The study results and analysis have been discussed in the fourth section. The final section represents the conclusion, recommendations, and suggestions.

Literature review

There is vast literature that has reported the FD relationships with different nations' economic growth and carbon emissions. In this modern world, financial development plays a vital role in the promotion of industry, agriculture, and education sectors. After World War II, this sector has gained special importance for government institutions to stabilize the exchange rate, maintain political stability, and implement fiscal and monetary policies. These factors are considered important contributors to economic growth and environmental quality.

The policymakers and researchers have failed to find the exact relationship of FD with economic growth and environmental quality. A long list of studies has shown that the FD sector improves the quality of the environment. Shobande and Ogbeifun (2022) revealed that FD reduces CO₂ and improves environmental quality in OECD countries. Abid et al. (2022) found that FD negatively affects the CO₂ in G8 countries by using FMOLS from 1990 to 2019. These studies argue that the developed financial sector inspires investors in environment-friendly technologies.

Apart from the above studies, various studies have explored that the FD sector is the major culprit of environmental pollution. From a global perspective, Khan et al. (2022) and Jiang and Ma (2019) explored that FD deteriorates the environmental quality by using the Generalized Method of Moments (GMM). Tahir et al. (2021) concluded that FD contributes to CO₂ emissions by using Fully Modified Least square (FMOLS), Dynamic Least Square (DOLS) and Pooled mean group from 1990 to 2014. These studies found that a healthy financial sector inspired the investors to attract the cheaper resources, which pollutes the environment.

Presently, each country desires to achieve sustainable development goals without losing environmental quality. The FD sector plays a significant role in sustainable economic growth. On the other hand, there is a controversial relationship between FD and economic development. Ahmed et al. (2022) pointed out that FD increases sustainable economic development in South Asian countries from 2000 to 2018. Rahman et al. (2020) empirically estimated that FD negatively impacted economic growth in Pakistan from 1975 to 2017. Asteriou and Spanos (2019) found that FD increases economic growth in 26 European countries before the financial crisis, while after the financial crisis, it declines economic growth. Amjad et al. (2021) examined the impact of FD on economic growth and the environment from 1990 to 2020 in Pakistan. The Nonlinear ARDL econometrics technique was employed to determine the empirical results. The study concluded that positive shocks of FD improve environmental quality and economic growth. Wang

et al. (2022) examined the impact of economic growth and environmental degradation in developed countries. They found that economic growth is a major cause of deteriorating environmental quality. Similarly, Rani et al., (2022) explored that FD not only increase the economic growth of SAARC countries but has badly effect on environmental quality.

Apart from financial development, there are also many determinants of economic growth and environmental quality. A skilled and high-quality labour force is critical to economic development. Countries with many skilled labour resources expand faster than those with many low-skilled workforces. Several studies have been conducted to explain the positive association between labour force participation and economic growth (Ziaei, 2022; Gouzoulis, 2022). However, a few studies concluded that a negative relationship between the labour force and economic growth and labour becomes a cause of environmental degradation (Alsamara, 2022).

Industrialization has huge impact in innovation, job creation, and optimal utilization of resources. Elfaki et al. (2022) investigated the impact of industrialization on economic growth in Indonesia. Using FMOLS and DOLS approaches, the studies concluded that industrialization positively contributes to economic growth. Ndiaya and Lv (2018) examined that industrialization increased economic growth in Senegal from 1960 to 2017. On the other hand, the study concluded that industrialization increases CO₂ emissions because most of the industrial sector is based on fossil fuel consumption, which is considered as the major contributor to CO₂ emissions. Zheng et al., (2021) found that industrialization increases CO₂ in the 29 provinces of China.

Globalization increases the interdependence among countries by developing economic and social relationships. Santiago et al. (2020) found that globalization positively increases economic growth in 24 Caribbean and Latin American developing countries from 1990 to 2015. Similarly, Guan et al. (2022) examined the effect of globalization in G-10 countries and explored that it certainly rise the environmental degradation in these countries. Moreover, Hassan et al. (2019) examined that globalization increases economic growth in Pakistan from 1970 to 2014, and on the other hand, globalization has a strong influence on carbon emissions. Furthermore, Khan et al. (2019) scrutinized the impact of globalization on CO₂ in Pakistan from 1971 to 2016. The study concluded that globalization positively increases carbon emissions.

Education enrolment has been used as a proxy to measure the educational level. It is divided into pre-primary, primary, secondary, and tertiary education. A vast literature has discussed that education enrollment increases economic growth (Nenbee & Danielle, 2021) and education also impacts carbon emissions (Maneejuk & Yamaka, 2021). Bano et al. (2018) identified the impact of human capital

through education on CO₂ in Pakistan. The study found that improvement in human capital declines CO₂ by accessing higher education. A low level of education declines human capital, which increases carbon emissions. Similar findings were obtained by Haini (2021) and Katircioglu et al. (2020).

Based on the above discussion, it is observed that there exists a linear relationship between financial development, economic growth and environmental quality in single-country studies. This study will contribute to the empirical literature by examining the association of FD with economic growth and CO₂ emissions using the nonlinear quadratic effect in South Asian countries.

Material and methods

The present study is an attempt to examine the effect of FD on economic growth and carbon emission in six South Asian countries named Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka, panel data for the period 1990–2020. The remaining two countries, Afghanistan and Maldives, are not included due to the unavailability of the data set. This study has been carried out in South Asian countries because, in these countries, the financial sector is growing rapidly and also these countries are keen to achieve sustainable economic development. Due to the massive poverty revealed in these countries, the population of these countries rely heavily on cheaper technologies which emit carbon and cause environmental degradation. This study uses the FD index as the key explanatory variable which is constructed by using the recommendations of the World Bank based on the financial stability, efficiency, depth and access to capital. For this purpose, bank credit to bank deposits, bank return on assets, domestic credit to the private sector and bank deposits to GDP annual time-series data are taken from the Global FD database. Further details of variables are listed in Table 1.

The study uses two models for analysis purpose.

The functional forms can be written as:

Table 1 Description of data

Symbols	Variables	Units
CO ₂	Carbon dioxide emission	Metric tons per capita
GDPPC	GDP per capita	Constant 2015 US\$)
FD	Financial development index	Index
LFTOT	Labor force	Total
EDU	School enrollment, tertiary	% gross
INDU	Industrialization	% of GDPPC
KOF	Globalization	Index

$$\text{GDPPC}_{it} = f(\text{FD}, \text{LFTOT}, \text{INDU}, \text{EDU}, \text{KOF}) \quad (1) \quad \text{FD}^* = -\frac{\alpha_1}{2\alpha_2} \quad (7)$$

$$\text{CO}_{2it} = f(\text{FD}, \text{LFTOT}, \text{INDU}, \text{EDU}, \text{KOF}) \quad (2)$$

The multiple regressions of both equations can be written as:

$$\begin{aligned} \text{LNGDPPC}_{it} = & \alpha_0 + \alpha_1 \text{FD}_{it} + \alpha_2 \text{LNLFTOT}_{it} \\ & + \alpha_3 \text{LNINDU}_{it} + \alpha_4 \text{LNEDU}_{it} + \alpha_5 \text{LNKOF}_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{LNCO}_{2it} = & \beta_0 + \beta_1 \text{FD}_{it} + \beta_2 \text{LNLFTOT}_{it} + \beta_3 \text{LNINDU}_{it} \\ & + \beta_4 \text{LNEDU}_{it} + \beta_5 \text{LNKOF}_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

In Eqs. 3 and 4, $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ and α_5 are coefficients of the first model whereas $\beta_1, \beta_2, \beta_3, \beta_4$ and β_5 indicate coefficients of the second model and ε_{it} is the residual. These models are not appropriate in the case of SAARC countries because the financial systems of these countries were not stable during 1990 to 2020. So this sector faced many ups and downs. In this equation, FD index has nonlinear behaviour. So, we use the quadratic term of FD.

$$\begin{aligned} \text{LNGDPPC}_{it} = & \alpha_0 + \alpha_1 \text{FD}_{it} + \alpha_2 \text{FD}_{it}^2 + \alpha_3 \text{LNLFTOT}_{it} \\ & + \alpha_4 \text{LNINDU}_{it} + \alpha_5 \text{LNEDU}_{it} + \alpha_6 \text{LNKOF}_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{LNCO}_{2it} = & \beta_0 + \beta_1 \text{FD}_{it} + \beta_2 \text{FD}_{it}^2 + \beta_3 \text{LNLFTOT}_{it} \\ & + \beta_4 \text{LNINDU}_{it} + \beta_5 \text{LNEDU}_{it} + \beta_6 \text{LNKOF}_{it} + \varepsilon_{it} \end{aligned} \quad (6)$$

The advantage of employing a square form is to detect the deviations from the constant returns to scale assumption, which explains the marginal effect (Sial et al., 2022). The square form can also be used to, country-specific effects and can compute from a single-mode by plugging country-specific incidence. After taking the partial derivative, we find the cut-off values of the FD index and GDPPC from Eqs. (5) and (6) as follows:

$$\frac{\partial \text{LNGDPPC}}{\partial \text{FD}} = \alpha_1 + 2\alpha_2 \text{FD} = 0$$

$$\text{FD}^* = -\frac{\beta_1}{2\beta_2} \quad (8)$$

The quadratic specification helps in determining the optimal value of FD at which the marginal effect of the FD and gross domestic product per capita reverse signs. This study uses its benchmark value to determine whether the economy is located before or after the threshold value.

Estimation technique

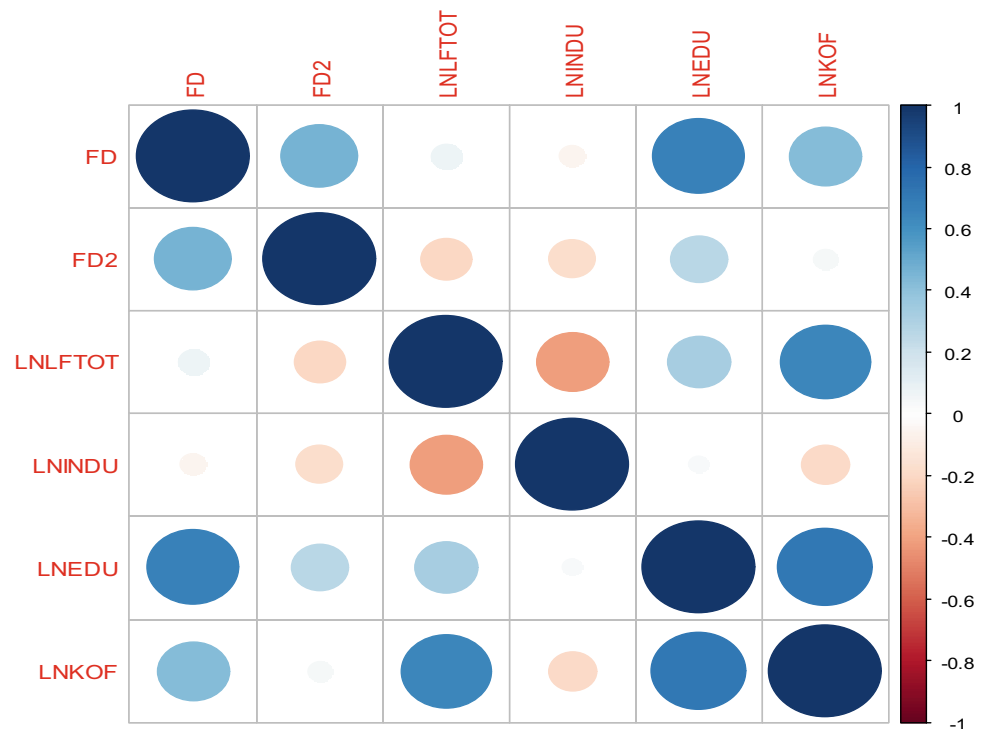
Parks (1967) proposed the algorithm-based feasible generalized least square (FGLS) method popularized by Kmenta (1986). The current study uses FGLS model for panel data estimation of six South Asian countries spanning from 1990 to 2020. The advantage of this model is that the cross-sectional discrepancies can be used to reflect differences in the slope coefficients' standard errors. Furthermore with the configuration, it is ease to control time-series autocorrelation, cross-sectional autocorrelation, and cross-sectional heteroscedasticity (Sial et al., 2022).

Empirical results

Table 2 provides a summary statistics of the variables. It can be observed that all mean values of variables are higher than their standard deviation. This indicates that all the data are under dispersed (Amjad et al. 2021). Based on the normality test, LNGDPPC, CO₂, LNLFTOT, LNEDU, and LNINDU are not normal at the 5% level. The kurtosis reveals the presence of outliers; it implies that variables are

Table 2 Descriptive statistics

	LNGDPPC	LNCO ₂	FD	LNINDU	LNKOF	LNLFTOT	LNEDU
Mean	7.1332	0.6966	0.3207	3.2117	3.8103	16.7377	2.1801
Median	7.0737	0.6474	0.3627	3.2769	3.8607	16.9929	2.2601
Maximum	8.3488	1.9611	2.2801	3.8089	4.1271	20.0195	3.3824
Minimum	6.2018	0.0876	-1.3939	2.4679	3.1355	12.2770	0.0931
Std. Dev	0.5410	0.4545	0.7910	0.3051	0.2495	2.2517	0.6821
Skewness	0.4158	0.9058	-0.1302	-0.2480	-0.8630	-0.5517	-0.5029
Kurtosis	2.4281	3.4735	2.7127	2.7023	3.1148	2.6228	2.8108
Jarque-Bera	6.6208	22.7897	0.9770	2.1757	19.4502	8.8373	6.8088
Probability	0.0365	0.0000	0.6135	0.3369	0.0001	0.0121	0.0332

Fig. 3 Correlation plot**Table 3** Detail results of FGLS

Variables	Dependent variable: LNGDPPC	Dependent variable: LN CO ₂
FD	−0.108* (0.021)	−0.208* (0.045)
FD ²	0.080* (0.016)	0.110* (0.034)
LNLFTOT	0.200* (0.008)	0.008 (0.017)
LNINDU	0.684* (0.046)	0.832* (0.098)
LNKOF	2.246* (0.084)	0.848* (0.179)
LNEDU	0.056*** (0.031)	0.181* (0.065)
Constant	−0.425 (0.312)	−5.745* (0.663)
Number of obs	156	156
Number of groups	26	26
Wald chi2(5)	2069.990	191.920
Prob > chi2	0.000	0.000

Author's estimation

not homogeneous across countries, rendering the pooled OLS model obsolete.

Figure 3 depicts the correlation plot of both models. At the same time, there is evidence of a perfect association between paired variables, so there is no problem with multicollinearity in the models.

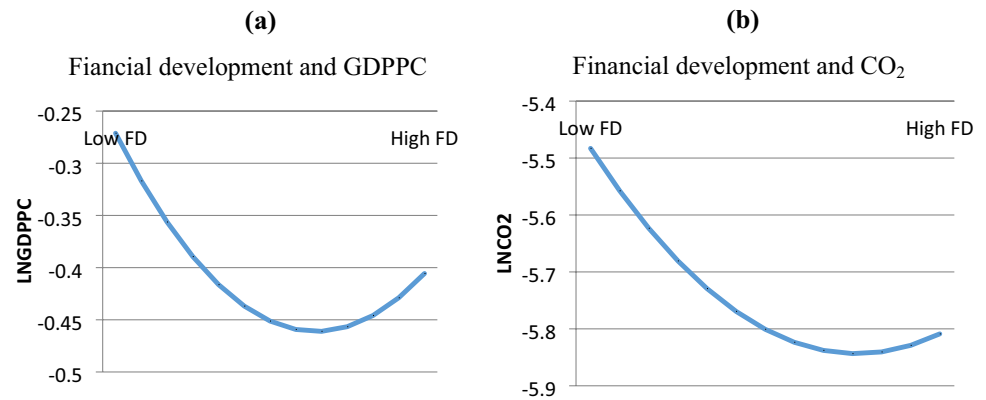
Table 3 presents the results of the Feasible Generalized Least Square (FGLS) model. The total number of years per cross-section is less than 30; assuming all variables are stationary, the results show that a one percent increase in the financial development index (FD) significantly declines

LNGDPPC by 0.108 percent in model 1. Similar results were explored by Rahman et al. (2020) in Pakistan, while the quadratic coefficient of FD shows a one percent increase in the FD significantly increases economic growth by 0.080 percent. Similar results were estimated by Ahmed et al. (2022) in South Asian countries. When we trace the negative level coefficient and positive quadratic coefficient of FD by using the mean, standard deviation and constant term, we propose a U-shaped relationship as presented in Fig. 4a.

In model 2, a 1% increase in the financial development index (FD) significantly decreases the LNCO₂ by 0.208 percent. The coefficient level of FD declines CO₂ (Similar results were obtained by Shobande & Ogbeifun 2022; Abid et al. 2022). At the same time, the quadratic coefficient of FD contributes positively to CO₂ (Their results were in line with Khan et al., 2022; Jiang & Ma, 2019). When we trace the negative level coefficient of FD and quadratic coefficient of FD by using the mean, standard deviation and constant term, we propose a U-shaped relationship (Fig. 4b).

Table 4 shows the cut-off value of FD of model 1 and model 2, showing the minimum requirements of the FD to achieve economic growth and carbon emissions.

Table 5 shows the linearized affect the economic growth and CO₂ by using the average value of the FD. In model 1, Bangladesh, Bhutan, India, and Pakistan lie on the negative side of Fig. 4a, while only two South Asian countries, Nepal and Sri Lanka, lie on positive side. This shows that FD increases economic growth in Nepal and Sri Lanka. Furthermore, in model 2, all South Asian countries lie on the

Fig. 4 Trace effect of the FD**Table 4** Cut-off value of FD

Coefficients	Model 1	Model 2
Level	-0.108	-0.208
Quadratic	0.080	0.110
cut-off value	0.674	0.945

Table 5 Linearized effect of economic growth and CO₂ based on mean value of FD

Country	Mean value of FD	Model 1	Model2
Bangladesh	0.503	-0.027	-0.097
Bhutan	-0.028	-0.113	-0.214
India	0.433	-0.039	-0.113
Nepal	0.774	0.016	-0.038
Pakistan	-0.535	-0.194	-0.326
Sri Lanka	0.777	0.016	-0.037

negative side of Fig. 4b. It means that FD decreases CO₂ emissions. We summarize that only Nepal and Sri Lanka are trying to achieve sustainable development. At the same time, the remaining South Asian countries failed to achieve sustainable development because these countries have lower per capita income. It is observed that most of South Asian countries have underdeveloped financial sectors and it faces many ups and downs, which failed to perform its function properly which effect the development process adversely in these countries.

After discussing the financial development, now we discuss the impact of the control variables on economic growth and CO₂ emissions. Labour force participation (LNLFTOT) has a significant and positive relation with economic growth. The results show that a 1% increase in the labour force brings a 0.200% increase in the economic growth of South Asian economies. It means a lot of the labour force has much work to do; therefore, the productivity of South Asian countries is high. They earn money for the survival of their families and help

reduce the burden on those countries' economies. The results are consistent with those (Ziaei, 2022; Gouzoulis, 2022). On the other hand, the labour force (LNLFTOT) significantly and positively impacts CO₂ emissions (Alsamara, 2022). In these countries, most of the workers are unskilled and prefer to work with old and cheaper machinery, which causes CO₂ emissions in the atmosphere.

Similarly, industrialization (LNINDU) has also a positive impact on economic growth (Elfaki et al., 2022; Ndiaya & Lv, 2018). The industrialization process improves productivity and provides job opportunities to skilled and unskilled persons, increasing the nation's development process. Industrialization (LNINDU) significantly increases CO₂ emissions (Zheng et al., 2021). All countries are under development in the South Asian region, and their industries utilized fossil fuel consumption which is the major source of CO₂ emissions.

Globalization (LNKOF) has a significant and positive relation with economic growth. The results show that a 1% increase in globalization brings a 2.246% increase in the economic growth in South Asian economies (Santiago et al., 2020; Hassan et al., 2019). It means more globalization increases the recognition of diversification of the products in different countries. Furthermore, globalization (LNKOF) also significantly increases CO₂ (Khan et al., 2019).

Moreover, education (LNEDU) positively impacts increasing economic growth. The results show that a 1% increase in LNEDU brings a 0.056% increase in economic growth. Information and skills have an essential role in raising awareness among the public to enhance economic growth. (The outcomes are similar to Nenbee & Danielle, 2021; Maneejuk & Yamaka, 2021). On the other hand, education positively influences the CO₂ in South Asian countries. One percent increase in the LNEDU statistically and significantly increases carbon emission by an average of 0.181% (Haini, 2021).

Conclusion and policy implication

The objective of this study is to achieve sustainable economic development without environmental degradation based on financial development. For this propose, the quadratic transformation of FD is used with GDP per capita and CO₂ in selected South Asian countries from 1990 to 2020. In the quadratic FD model, the level coefficient of FD has a negative sign. In contrast, the quadratic coefficient of FD has a positive sign, which proposes the U-shaped relationship between GDP per capita and carbon emissions. It means an initial increase in the FD decreases GDP per capita and CO₂ because the infrastructure is not so much developed at this stage, while after the maturity stage of FD GDP per capita and CO₂ increase because of the infrastructure improvement. The cut-off value of FD shows the minimum optimal value of the U-shaped curve concerning GDP per capita and carbon emissions. The linearized effect of FD shows that only two countries, Nepal and Sri Lanka, have achieved sustainable growth.

Furthermore, the remaining independent variables, labour force participation, industrialization, globalization and school education enrolment, positively increase GDP per capita and CO₂ in South Asian countries. This study recommends that the financial institutions should provide funds to those industries that use environment-friendly technologies. Before providing funds, the financial institution must make sure that the investment has been made in those major projects which use renewable energy resources and restrict funds to highly polluting industries.

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Declarations

Conflict of interest The authors have not disclosed any conflict of interest.

Data availability Enquiries about data availability should be directed to the authors.

References

- Abid A, Mehmood U, Tariq S, Haq ZU (2022) The effect of technological innovation, FDI, and FDI on CO₂ emission: evidence from the G8 countries. *Environ Sci Pollut Res* 29(8):11654–11662. <https://doi.org/10.1007/s11356-021-15993-x>
- Ahmed F, Kousar S, Pervaiz A, Shabbir A (2022) Do institutional quality and FD affect sustainable economic growth? Evidence from South Asian countries. *Borsa Istanbul Rev* 22(1):189–196. <https://doi.org/10.1016/j.bir.2021.03.005>
- Alsamara M (2022) Do labor remittance outflows retard economic growth in Qatar? Evidence from nonlinear cointegration. *Q Rev Econ Financ* 83:1–9. <https://doi.org/10.1016/j.qref.2021.11.002>
- Amjad MA, Asghar N, Rehman HU (2021) Can FD help in raising sustainable economic growth and reduce environmental pollution in Pakistan? evidence from non linear ARDL model. *Rev Econ Dev Stud* 7(4):475–491. <https://doi.org/10.47067/reads.v7i4.406>
- Asteriou D, Spanos K (2019) The relationship between FD and economic growth during the recent crisis: Evidence from the EU. *Financ Res Lett* 28:238–245. <https://doi.org/10.1016/j.frl.2018.05.011>
- Bano S, Zhao Y, Ahmad A, Wang S, Liu Y (2018) Identifying the impacts of human capital on CO₂ in Pakistan. *J Clean Prod* 183:1082–1092. <https://doi.org/10.1016/j.jclepro.2018.02.008>
- Elfaki KE, Khan Z, Kirikkaleli D, Khan N (2022) On the nexus between industrialization and carbon emissions: evidence from ASEAN + 3 economies. *Environ Sci Pollut Res*. <https://doi.org/10.1007/S11356-022-18560-0>
- Friedman L (2021). What is COP26? And other questions about the big U.N. Climate Summit. *The New York Times*. <https://www.nytimes.com/article/what-is-cop26-climate-change-summit.html>
- Germanwatch (2021) Global climate risk index | Germanwatch e.V. <https://www.germanwatch.org/en/crri>
- Gouzoulis G (2022) Financialisation, globalisation, and the industrial labour share: a comparison between Iran and Thailand. *Ind Relat J* 53(1):35–52. <https://doi.org/10.1111/IRJ.12353>
- Guan C, Rani T, Yueqiang Z, Ajaz T, & Haseki MI (2022). Impact of tourism industry, globalization, and technology innovation on ecological footprints in G-10 countries. *Economic Research-Ekonomska Istraživanja*, 1–17. <https://doi.org/10.1080/1331677X.2022.2052337>
- Haini H (2021) Examining the impact of ICT, human capital and carbon emissions: evidence from the ASEAN economies. *Int Econ* 166:116–125. <https://doi.org/10.1016/j.inteco.2021.03.003>
- Hassan ST, Xia E, Huang J, Khan NH, Iqbal K (2019) Natural resources, globalization, and economic growth: evidence from Pakistan. *Environ Sci Pollut Res* 26(15):15527–15534. <https://doi.org/10.1007/s11356-019-04890-z>
- Islam M (2021) Does FD cause environmental pollution? Empirical evidence from South Asia. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-16005-8>
- Jiang C, Ma X (2019) The impact of FDI on carbon emissions: a global perspective. *Sustainability* 11(19):5241. <https://doi.org/10.3390/su11195241>
- Jiang T, Huang S, Yang J (2019) Structural CO₂ from industry and energy systems in China: an input-output analysis. *J Clean Prod* 240:118116. <https://doi.org/10.1016/j.jclepro.2019.118116>
- Katircioglu S, Katircioglu S, Saqib N (2020) Does higher education system moderate energy consumption and climate change nexus? Evidence from a small island. *Air Qual Atmos Health* 13(2):153–160. <https://doi.org/10.1007/S11869-019-00778-6>
- Khan MK, Teng JZ, Khan MI, Khan MO (2019) Impact of globalization, economic factors and energy consumption on CO₂ emissions in Pakistan. *Sci Total Environ* 688:424–436. <https://doi.org/10.1016/j.scitotenv.2019.06.065>
- Khan H, Weili L, Khan I (2022) Institutional quality, FD and the influence of environmental factors on carbon emissions: evidence from a global perspective. *Environ Sci Pollut Res* 29(9):13356–13368. <https://doi.org/10.1007/s11356-021-16626-z>
- Kmenta J (1986) Elements of econometrics, 2nd edn. Macmillan, New York
- Maneejuk P, Yamaka W (2021) The impact of higher education on economic growth in ASEAN-5 countries. *Sustainability* 13(2):520. <https://doi.org/10.3390/su13020520>

- Ndiaya C, Lv K (2018) Role of industrialization on economic growth: the experience of Senegal (1960–2017). *Am J Ind Bus Manag* 8(10):2072. <https://doi.org/10.4236/ajibm.2018.810137>
- Nenbee SG, Danielle IE (2021) Primary school enrolment, public spending on education and economic growth in Nigeria. *Mediterr J Soc Sci* 12(5):103–103. <https://doi.org/10.36941/mjss-2021-0048>
- NOAA (2020). Global climate report- annual 2020. <https://www.ncdc.noaa.gov/sotc/global/202013>.
- Parks RW (1967) Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *J Am Stat Assoc* 62(318):500–509. <https://doi.org/10.1080/01621459.1967.10482923>
- Rahman A, Khan MA, Charfeddine L (2020) Does financial sector promote economic growth in Pakistan? Empirical evidences from Markov switching model. *SAGE Open*. <https://doi.org/10.1177/2158244020963064>
- Rani, T., Wang, F., Rauf, F., & Ali, H. (2022). Linking personal remittance and fossil fuels energy consumption to environmental degradation: evidence from all SAARC countries. *Environ Dev Sustain*, 1–22. <https://doi.org/10.1007/s10668-022-02407-2>
- Santiago R, Fuinhas JA, Marques AC (2020) The impact of globalization and economic freedom on economic growth: the case of the Latin America and Caribbean countries. *Econ Chang Restruct* 53(1):61–85. <https://doi.org/10.1007/s10644-018-9239-4>
- Shobande OA, Ogbefun L (2022) The criticality of FD and energy consumption for environmental sustainability in OECD countries: evidence from dynamic panel analysis. *Int J Sustain Dev World Ecol* 29(2):153–163. <https://doi.org/10.1080/13504509.2021.1934179>
- Sial MH, Arshed N, Amjad MA, Khan YA (2022) Nexus between fossil fuel consumption and infant mortality rate: a non-linear analysis. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-022-19975-5>
- Tahir T, Luni T, Majeed MT, Zafar A (2021) The impact of FD and globalization on environmental quality: evidence from South Asian economies. *Environ Sci Pollut Res* 28(7):8088–8101. <https://doi.org/10.1007/s11356-020-11198-w>
- Usman M, Hammar N (2021) Dynamic relationship between technological innovations, financial development, renewable energy, and ecological footprint: fresh insights based on the STIRPAT model for Asia Pacific Economic Cooperation countries. *Environ Sci Pollut Res* 28(12):15519–15536. <https://doi.org/10.1007/s11356-020-11640-z>
- Wang F, Rani T, Razzaq A (2022) Environmental impact of fiscal decentralization, green technology innovation and institution's efficiency in developed countries using advance panel modelling. *Energy Environ*. <https://doi.org/10.1177/0958305X221074727>
- WMO (2020). The state of the global climate 2020. <https://public.wmo.int/en/ourmandate/climate/wmo-statement-state-of-global-climate>
- Zheng S, Wang R, Mak TM, Hsu SC, Tsang DC (2021) How energy service companies moderate the impact of industrialization and urbanization on CO₂ in China? *Sci Total Environ* 751:141610. <https://doi.org/10.1016/j.scitotenv.2020.141610>
- Ziaei S (2022) The impacts of household social benefits, public expenditure on labour markets, and household financial assets on the renewable energy sector. *Renew Energy* 181:51–58. <https://doi.org/10.1016/j.renene.2021.09.017>

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Authors and Affiliations

Tayyaba Rani¹  · Muhammad Asif Amjad² · Nabila Asghar³ · Hafeez Ur Rehman⁴

✉ Tayyaba Rani
tayyabarani@stu.xjtu.edu.cn

Muhammad Asif Amjad
m.asifamjad22@gmail.com

Nabila Asghar
nabeela.asghar@ue.edu.pk

Hafeez Ur Rehman
hafeez.rehman@umt.edu.pk

² Department of Economics and Statistics, University of Management and Technology, Lahore, Pakistan

³ Department of Economics, Division of Management and Administrative Science, University of Education, Lahore, Pakistan

⁴ Department of Economics and Statistics (HSM), University of Management and Technology, Lahore, Pakistan

¹ School of Economics and Finance, Xi'an Jiaotong University, Xi'an, Shaanxi, China