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Exploring the moderating effect of globalization, financial development and environmental degradation nexus: a roadmap to sustainable development

Tayyaba Rani[1] · Muhammad Asif Amjad[2] · Nabila Asghar[3] · Hafeez Ur Rehman[2]

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Abstract
Financial development is a multidimensional process that contributes to economic growth but sometimes it has a devastating effect on climate change. No country can achieve sustainable development goals without caring the environmental quality. The present study investigates the moderating role of globalization (KOF) in determining the financial development (FD) on environmental degradation in the SAARC countries from 1990 to 2020. The long-run coefficients are estimated using the panel quantile regression (PQR) approach at lower, middle and upper quantile groups. The study shows the U-shaped relationship across three quantile groups based on financial development and carbon emissions. The moderator globalization (KOF) brings up the change in the turning point and flattens before the maturity of the U-shaped curve at the middle quantile while flattens after the maturity of the U-shaped curve at the upper quantile. The study recommends that by using energy-efficient technologies, better financial sector interaction with globalization enhances the environmental quality in SAARC countries.

Keywords Financial development · Sustainable developments · Environmental degradation · Globalization

JEL Classification B26 · F6 · R11

✉ 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

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

[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

1 Introduction

Nowadays, global warming has been the most debatable topic among researchers, governments, policymakers, and international organizations all over the world. To achieve higher economic growth, most of the economies rely on fossil fuel consumption by the massive industrialization (Abad-Segura et al. 2020; Hsu et al. 2021). It badly pollutes the environmental quality which causes global warming, flooding, melting ice caps, and climate vulnerability (Amjad et al. 2021b). The most recent conference on climate change COP26 paid special attention to decline greenhouse gases. It was warned that if there is no collective effort to decline environmental pollution, then no country can achieve sustainable development goals. The IPCC (2022) estimated the concentration of CO_2 emissions in the atmosphere was around 278 ppm from 1750 to 1800, while in March 2021, it increased 50% and reached to 417 ppm. Furthermore, it was emphasized that if we fail to reduce carbon concentration in the atmosphere, it will double from the pre-industrial stage in 2035 and reach 556 ppm (Wang et al. 2022a, 2022b).

To achieve the sustainable development goals (SDG), many researchers have used financial inclusion (Amjad et al. 2021a; Kim et al. 2018; Rani et al. 2022a, 2022b; Saleem et al. 2022). The development of a country depends upon its strong and reliable financial system. No doubt, the financial system provides saving mobilization channels, capital allocation, risk diversification, investment monitoring, lower borrowing costs, and transaction facilitation. The financial institutions may change consumer patterns, increase investment flows, and improve R & D in technical activities in contemporary economic settings (Xu, 2022). Policymakers now agreed that it is impossible to achieve the SDG without controlling the environmental pollution.

The policymakers have failed to investigate the exact relationship between financial development (FD) sector and environmental pollution. There are numerous studies available in the literature which has pointed out that FD sector deteriorates the environment due to a poor financial system (Shen et al. 2021; Tahir et al. 2021). Usually, in developing countries, the FD sector is not developed. These countries face the problem of credit facilities which force their industries to use outdated technologies that emit massive carbon emissions. While on the other hand, many studies have examined the role of financial development in improving the environmental quality. These studies evaluated that the financial sector is critical for improving productive units, institutions, and markets, substantially contributing to economic growth (Bindu et al. 2021; Das & McFarlane, 2021; Usman & Hammar, 2021). The easy access to loans for small- and medium-sized industries motivates investors to invest in environment friendly technologies that not only generate employment opportunities but also reduce income disparity.

The present study is carried out in South Asian Association for Regional Cooperation (SAARC) countries to formulate consistent policies for improving environment with the inclusion of FD sector. The most recent study by Rani et al. (2022a, 2022b) conducted on SAARC countries explored that the FD sector deteriorates the environmental quality. Due to poor financial sectors, there is lack of credit facilities available to investors forcing them to use outdated technologies run by polluted energy, which causes massive CO_2 emissions.

Figure 1 shows the upward trend of CO_2 emissions in SAARC economies, which have been continuously increasing in the last thirty years. It is also observed that the Maldives is the major contributor to CO_2 emissions. India is the second one which spreads pollution the region. Pakistan is in the third position, while Afghanistan discharges lowest emissions.

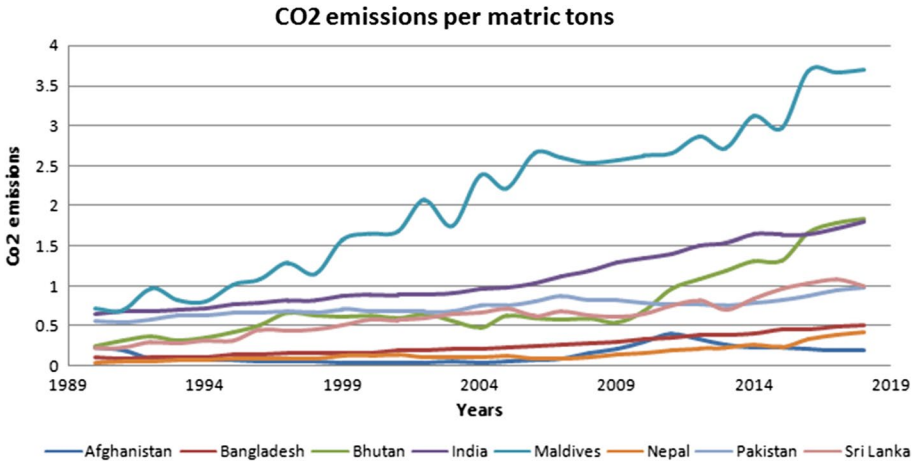

Fig. 1 Carbon emissions in SAARC countries

A question arises here how does this financial inclusion improve the environmental quality? Sheraz et al. (2021) used globalization as the moderator with the inclusion of FD sector to improve the environmental quality. Since the beginning of the present century, through globalization, the movement of commodities and services between countries has risen. This has generated competition between developed and developing countries. Therefore, countries are putting forth significant efforts to improve their welfare and physical and human capital (Du et al. 2022). Researchers are of opinion that globalization provides ecologically beneficial technology; the quality of the environment will improve as trade volume and foreign direct investment increase (Ahmad et al. 2021).

This study is an attempt to explore the moderating role of globalization in determining the FD sector with CO_2 emissions in SAARC countries. In G-20 countries, Sheraz et al. (2021) investigated the moderation effect of globalization with linear financial inclusion on environmental quality. The present study follows Rani et al. (2022a, 2022b) who found that financial development has a U-shaped relationship with carbon emissions in SAARC countries. The current study is very novel as it uses the moderation effect of globalization (KOF index) with the interaction of the U-shaped curve FD sector on CO_2 emissions. In addition, the moderating effect of globalization is analyzed to promote environmental quality. The significance of this study is to fill the research gap through nonlinear analysis of financial development by using the moderation effect of globalizations because not many studies have empirically verified this relationship in SAARC countries. This study will try to verify the null hypothesis that the moderation effect of globalization does not change the turning point of the U-shaped curve of the FD and CO_2 emissions in SAARC countries.

The primitive contributions of this research are as follows: (1) it analyzes the panel data of eight SAARC economies during 1990 to 2020, which is the latest three-decade after the strategy of ecological civilization proposed by the SAARC governments. (2) A nonlinear estimation approach as panel quantile regression (QPR) at the lower, middle, and upper quartiles (Q1, Q2, and Q3) is used.

The remainder of the study is organized as follows. The literature review is presented in Sect. 2. Data, methodology and theoretical model are explained in Sect. 3. Results and

discussion are presented in Sect. 4, whereas conclusion and policy recommendations are given in Sect. 5.

2 Review of literature

Previous studies have discussed the link between financial development (FD) sector and CO_2 emissions worldwide. Nowadays, the FD sector has got special importance for agriculture, industries, education, and service sectors. The economic activities in these sectors directly affect the environmental quality. However, the researchers are failed to investigate the acceptable connection between FD and environmental quality. The current literature have pointed out that improvement in the FD sector deteriorates the environmental quality through extensive CO_2 emissions as the development in the financial sector motivates the investors to invest in cheaper technologies which increase CO_2 emissions (Jiang & Ma, 2019; Khan et al. 2022; Shahbaz et al. 2020a, 2020b). Contrary to the above, several studies have examined that the FD enhances the quality of environment. The strong and healthy financial sector induces the investment in environment friendly technologies which reduce CO_2 emissions (Abid et al. 2022; Shobande & Ogbeifun, 2022; Farooq et al. 2022; Shahbaz et al. 2013). All of the above-mentioned studies have shown the linear association between FD and environmental quality. Due to many fluctuations in the financial sectors in all the countries of the world, it is quite difficult to capture the true picture of environmental quality by treating FD as linear. Still, not many studies have analyzed the nonlinear quadratic relationship between FD and CO_2 emissions. Rani et al. (2022a, 2022b) explored a U-shaped association between FD and CO_2 emissions in South Asian countries.

There are limited studies which have explored the connection between FD and CO_2 emissions by using the moderator variable of FD, which modifies the impact of FD on the environment. Ojeyinka and Osinubi (2022) worked 22 sub-Saharan countries to find the association between FD and CO_2 emissions. The results of the study show that FD is negatively associated with sustainable development, but the inclusion of globalization increases the CO_2 emissions. Similarly, Sheraz et al. (2021) used globalization as a moderator with the FD on CO_2 emissions in G20 countries. The study showed that the financial sector enhances CO_2 emissions in the complete sample, but this effect becomes negative with the interaction of the moderator. Additionally, the financial sector enhanced CO_2 emissions in the subsample of developing countries following interaction. Rani et al. (2022a) have found that FD not only improves the economic growth of a country but also damages the environmental quality of the economies. Liu et al. (2019) pointed out that it is difficult for policymakers to predict whether FD has a good or bad impact on CO2. Furthermore, the use of different econometric technique, changes in sample size, and proxies may produce mixed results (Amin et al. 2020).

Several academicians have examined the impact of globalization on CO_2 emissions. Akadiri et al. (2019) conducted a ground breaking analysis of KOF in Turkey from the year 1970 to 2014. The outcomes indicate that KOF reduces CO_2 emissions. Salahuddin et al. (2019) pointed out that KOF has no harmful effect on the environment in sub-Saharan African countries. Zaidi et al. (2019) explored that KOF increases the CO_2 emission in OPEC countries. Additionally, Shahbaz et al. (2019) evaluated the link between KOF and CO_2 emissions in 87 OECD economies and pointed out that KOF is beneficial in reducing CO_2 emissions. In addition Chen et al. (2020) focused on the impact of KOF on CO_2 emissions in 36 OECD countries. The results showed that KOF has a significant negative impact on CO_2 emissions. Moreover, Kirikkaleli et al. (2022)

analyzed the impact of KOF and energy consumption on carbon emissions in Bangladesh from 1972 to 2016. The result showed that KOF is the main driving factor in reducing CO_2 emissions, while fossil fuels increase the chances of ecological issues. Similarly, Rahman (2020) studied the effect of KOF on CO_2 emissions. The outcomes showed that KOF promotes environmental excellence. Wang et al. (2021) investigated the influence of KOF in 137 countries from 1970 to 2014 and discovered that KOF reduces CO_2 emissions in developed countries. However, Guan et al. (2022) claimed that KOF had become a reason for increasing environmental degradation in G-10 countries. From the review of the above literature, it can be observed that some researchers found that KOF reduces CO_2 emissions. While, few researchers have found the opposite results and concluded that KOF increases CO_2 emissions. These contradictory results may be due to certain factors, like the use of different sample sizes and estimation techniques. This calls for the need to analyze the relationship between the variables using recent econometric development.

Education has become an integral part of human life, which has changed the way of thinking. It has not only changed the lifestyle but also brought about changes in the techniques of production, which help in reducing CO_2 emissions by encouraging R&D. Furthermore, education has become an effective instrument in the fight against climate change, which has exerted a bad impact on agricultural productivity in all countries in the world. Researchers and academicians are agreed to reduce CO_2 emissions through education. Bano et al. (2018) explored that increasing education is the most effective way of handling undesirable environmental factors in Pakistan. The study concluded that people should be made aware of the use of green technologies rather than conventional energy sources. Zafar et al. (2020) introduced a new paradigm to study the impact of education on the environment in OECD economies and explored a significant impact of quality education on environmental sustainability. Katircioglu et al. (2020) concluded that information still has an essential role in mitigating environmental degradation. Mukherjee (2018) opined that different types of courses, seminars, and conferences related to CO_2 emissions and harmonizing society raise awareness among the public. The above discussion reveals that education is an important tool that can be used to reduce CO_2 emissions particularly in developing countries.

Economic growth and environmental pollution go side by side because fossil fuel energy consumption in industries for producing output has become a major cause of greenhouse gases, which are harmful to living creatures. Many researchers have explored the relationship amid economic growth and CO_2. Beside it, Ahmed et al. (2022) focused a relationship between China's economic growth and CO_2 emissions. The results show that on one side, rapid industrialization increases the development process, but on the other hand, it deteriorates ecological excellence. Similarly, Tang and Tan (2015) conducted studies on Vietnam to analyze the link between growth, foreign investment and CO_2 emissions. The results show that growth and investment have a meaningful impact on the ecological footprint. Additionally, Razak et al. (2013) investigated the link amid economic growth and environmental pollution by using the IPAT-fuzzy model. The results show that Malaysian growth is also a cause of ecological footprint. Several studies have shown that population exerts bad impact on environment due to the lack of resources, rising demand for housing, massive consumption of fossil fuels, and huge demand for medical and transport facilities, which disturb the sustainability of the environment (Kim et al. 2020; Yang & Wang, 2020).

The review of above literature brings up that limited studies have examined the moderation effect of KOF with FD on CO_2 emissions. Furthermore, the moderation effect of KOF

with linear and quadratic FD on CO_2 emissions has not been researched properly. This study is an attempt to explore such link in the context of SAARC countries.

3 Theoretical framework

The theoretical model of this study is motivated by the EKC hypothesis. This study examines the impact of the FD sector on CO_2 emissions in SAARC countries. The FD influences the CO_2 emissions through income, capital, technology, and polices (Yuxian & Chen, 2011). The researchers have failed to identify the exact association between FD and CO_2 emissions. The developed countries have developed FD sector which induces the investors to invest in environment friendly technologies (Abid et al. 2022; Shobande & Ogbeifun, 2022; Farooq et al. 2022; Godil et al. 2021; Shahbaz et al. 2013). On the other hand, the developing countries having poor FD sector cannot properly tackle the problem of CO_2 emissions and poor FD sector encourages investment in cheaper environment polluting technologies (Jiang & Ma, 2019; Khan et al. 2022; Shahbaz et al. 2020a, 2020b; Tahir et al. 2021). The present study is conducted in the SAARC countries where the FD sector has observed many fluctuations due to 1990s oil shocks, 9/11 incident, war on terrorism, financial crisis, COVID-19 pandemics, and the most recent Russia-Ukrain war. This indicates that FD sector in these countries will behave nonlinear quadratic relationship with CO_2 either U-shaped or inverted U-shaped relationship. Followed by Rani et al. (2022a, 2022b), FD sector proposed the U-shaped relationship with CO_2 emissions in South Asian countries.

The U-shaped relationship demonstrates that poor FD increases CO_2 emissions, while developed FD sector degrades the environment (Rani et al. 2022a, 2022b). This study uses KOF index as the moderator with the FD sector to determine CO_2 emissions. The moderator variable changes the turning point of the U-shaped curve. In this study, the inclusion of moderator KOF with both linear and quadratic FD will change turning point of the U-shaped curve. The inverted U-shaped Kuznets' curve shows that the inclusion of KOF in linear FD deteriorates the environment, while the inclusion of KOF in quadratic FD improves the CO2 (Sardar & Rehman, 2022). Figure 2 shows the theoretical framework of this study.

4 Data and methodology

The present study uses panel data from SAARC countries for the period 1990–2020. The data have been collected to analyze the effect of FD on environmental deterioration and the moderation effect of globalization. The reason for selecting SAARC countries is that in these countries, CO_2 emissions were recorded at an average of 1.672 metric tons per capita in 2019, which was higher than all lower-income countries (WDI-2022). The environmental degradation is dependent variable which is proxied by CO_2 emissions. The main independent variable is FD. Globalization is proxied by the KOF index and is used as a moderator variable in this study. Furthermore, economic growth is proxied by GDP per capita and urban populations are denoted by URPOP, which serve as the control variables. These variables are taken into the natural logarithm for elasticity-base comparison whose main purpose is to minimize the outlier-based heteroskedasticity (Benoit 2011). Table 1 presents the unit and data source of the variable.

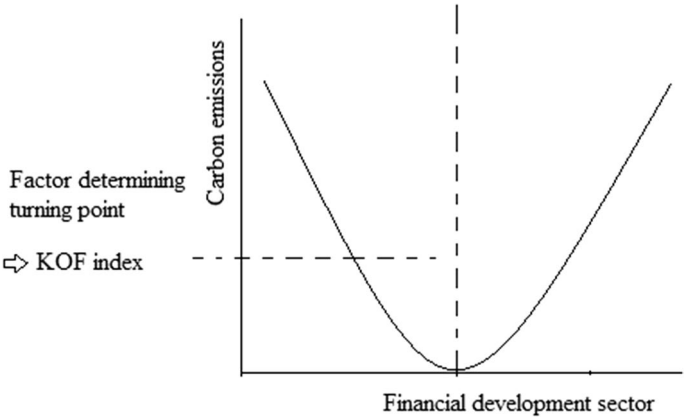

Fig. 2 Theoretical framework

4.1 FD index

Several proxies of FD have been used in the literature, such as the FD index of M2 and liquid liabilities. According to Jalil and Feridun (2011) and Creane et al. (2006), M2 and liquid liabilities do not accurately represent the FD index because M2 only monitors currency consistency, while liquid liabilities only gauge the size of the financial sector. In several studies, domestic credit to the private sector is often used as a proxy for the FD index (Boutabba, 2014; Hunjra et al. 2020). However, this proxy only assesses the FD index depth. Still, the researchers could not find the suitable FD proxy. According to the World Bank's global FD report (2016), FD has been measured by proxy variables regarding financial depth, access, efficiency, and stability (World Bank, 2016). This study constructs the FD index by combining four FD proxies based on depth, access, efficiency, and stability. This index serves as more accurate and dependable data. This study uses bank credit to bank deposits (%) as an indicator of stability, bank return on assets (%) as an indicator of efficiency, domestic credit to the private sector (%) as an indicator of depth, and firms using banks to finance investments (%), an indicator for access and bank deposits to GDP (%) as an indicator for others.

Table 1 Description of the variables

Symbols	Variables	Units	Sources
CO_2	Carbon emissions	Metric ton	WB (2020)
FD	FD index	Index	Global FD 2021
KOF	Globalization	KOF Globalization Index	Gygli et al. (2019)
EDUI	Government expenditure on education, total	% of GDP	WDI 2021
GDPPC	GDP per capita	constant 2015 US$	WDI 2021
URPOP	Urban population	% of total population	WDI 2021

4.2 Model specification and methodology

Based on the current literature, this study examines the association between FD and CO_2 emissions by using the moderating variable along with control variables:

$$CO_{2it} = f(FD_{it}, KOF_{it}, EDUI_{it}, GDPPC_{it}, URPOP_{it}, \varepsilon_{it}) \tag{1}$$

where CO_2 is used as a proxy for environmental degradation, FD is the main explanatory variable; KOF is the moderating variable of FD. While EDUI, GDPPC and URPOP are the control variables. Equation (1) can be represented in econometric form as

$$CO_{2it} = \alpha_0 + \alpha_1(FD_{it}) + \alpha_2(KOF_{it}) + \alpha_3(EDUI_{it}) + \alpha_4(LNGDPPC_{it}) + \alpha_5(LNURPOP_{it}) + \varepsilon_{it} \tag{2}$$

Following Sheraz et al. (2021), this study uses globalization (KOF) as a moderator factor to solve this problem. In Eq. (3), the interaction between FD and KOF is used.

$$\begin{aligned} CO_{2it} =& \beta_0 + \beta_1(FD_{it}) + \beta_2(KOF_{it}) + \beta_3\left(FD_{it} \times KOF_{it}\right) + \beta_4(EDUI_{it}) \\ &+ \beta_5(LNGDPPC_{it}) + \beta_6(LNURPOP_{it}) + \varepsilon_{it} \end{aligned} \tag{3}$$

FD sector has a nonlinear relationship with CO_2 emissions by the recommendation of Table 2. In this study, we employed the FD and the square of the FD term which is presented in Eqs. (4), the moderating variable is likewise applied to the quadratic FD.

$$\begin{aligned} CO_{2it} =& \gamma_0 + \gamma_1(FD_{it}) + \gamma_2(FD_{it}^2) + \gamma_3(KOF_{it}) \\ &+ \gamma_4(FD_{it} \times KOF_{it}) + \gamma_5(FD_{it}^2 \times KOF_{it}) \\ &+ \gamma_6(EDUI_{it}) + \gamma_7(LNGDPPC_{it}) \\ &+ \gamma_8(LNURPOP_{it}) + \varepsilon_{it} \end{aligned} \tag{4}$$

where α_0 β_0 and γ_0 are the intercept terms, while $\alpha_1, \alpha_2, \ldots \alpha_5$ are coefficients of the model, whereasβ_1,β_2,…..β_6 indicate coefficients of the second model,γ_1, $\gamma_{2,\ldots\ldots}\gamma_8$ are coefficients of the third model and ε_{it} is the residual. FD of SAARC economies was not stable from 1990 to 2020. Therefore, in this case, Model 3 is not appropriate. So, Eq. 4 is appropriate which demonstrates the moderation effect of the KOF turning point of the U-shaped relationship

Table 2 Summary statistics *Source: Authors' own calculations*

	CO_2	FD	KOF	LNGDPPC	LNURPOP	EDUI
Mean	0.771	0.813	42.266	7.132	3.219	0.000
Median	0.617	0.557	42.00	6.980	3.251	0.049
Maximum	3.778	3.024	62.00	9.231	3.745	1.776
Minimum	0.037	0.001	23.00	5.183	2.181	-2.357
Std. Dev	0.765	0.729	11.09	0.913	0.324	1.000
Skewness	1.908	1.113	0.038	0.534	-0.683	-0.409
Kurtosis	6.825	3.474	2.014	2.793	3.185	2.409
Jarque–Bera	301.74	53.548	10.106	12.247	19.648	10.518
Probability	0.000	0.000	0.006	0.002	0.000	0.005
Observations	248	248	248	248	248	248

curve. The turning point is estimated by using the first derivate of Eq. 4 with respect to FD and set it equal to zero as follows:

$$\frac{\partial CO_{2it}}{\partial FD_{it}} = \gamma_1 + 2\gamma_2 FD_{it} + \gamma_4 KOF_{it} + 2\gamma_5 FD_{it} KOF_{it} = 0$$

$$FD^*_{it} = \frac{-\gamma_1 - \gamma_4 KOF_{it}}{2(\gamma_2 + \gamma_5 KOF_{it})} \tag{5}$$

Furthermore, the shifting of the turning point depends upon the moderator KOF. So, we use partial derivative concerning KOF as follows:

$$\frac{\partial FD^*_{it}}{\partial KOF_{it}} = \frac{(\gamma_1\gamma_5 - \gamma_2\gamma_4)}{2(\gamma_2 + \gamma_5 KOF_{it})^2} \tag{6}$$

In Eq. 6, the denominator has a quadratic term which shows a positive effect, so the shifting of the turning point depends upon the coefficients of the numerator $(\gamma_1\gamma_5 - \gamma_2\gamma_4)$. The positive value of the numerator shows the turning point will shift rightward, while the negative numerator will shift the turning point leftward. However, the flattens and steepens depend upon the mathematical sign of γ_5. If γ_5 is negative, then the U-shaped curve will be flattened otherwise steepens (Haans et al. 2016).

4.3 Estimation technique

The panel quantile regression (PQR) technique presented by Koenker and Bassett (1978) is applied. Since most of the series are not stationary, pool OLS does not offer accurate results. As the series contains many outliers, PQR is an appropriate technique as it is quite useful for reducing cross-sectional heteroscedasticity and autocorrelation (Hassan et al. 2020). The data in this study have more than 30 observations for each country, and it is appropriate to apply both panel unit root and co-integration tests (Pedroni, 2004).

5 Results and discussion

Table 2 presents the results of descriptive statistics. The high Kurtosis values indicate the presence of outliers, showing that the data are not linear across countries. The Jarque–Bera values are quite high, and the probability values are statistically significant, indicating that the series is not normally distributed.

The correlation plot in Fig. 3 shows pairwise correlation between the variables. It is displayed through different shades. The dark red color presented the perfect positive correlation between variables. The light red color between independent variables shows lower multicollinearity issue.

The VIF results are presented in Table 3. The values of VIF are less than 10 which indicated no issue of multicollinearity.

This study uses Levin, Lin & Chu (LLC), Im Pesaran and Shin (IPS) and Augmented Dickey-Fuller (ADF) unit root tests to identify the order of integration of all the variables included in the model. The results presented in Table 4 show that all variables have a mixed order of integration.

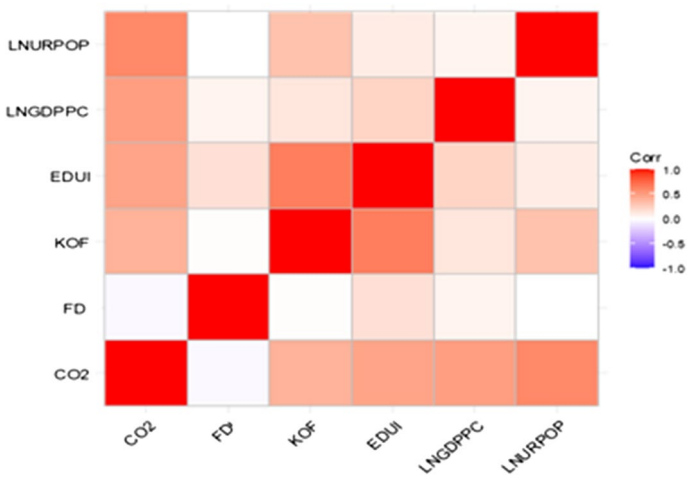

Fig. 3 Correlation Plot

Table 3 Variance inflation factor

Variables	VIF	1/VIF
FD	1.37	0.73
KOF	2.05	0.488
EDUI	3.73	0.268
LNGDPPC	3.16	0.317
LNURPOP	1.76	0.568
Mean VIF	2.41	

Table 4 Results of panel unit root test

	LLC	IPS	ADF
At level			
CO_2	−2.899*	6.4983	4.105
FD	0.540	1.346	14.697
KOF	−2.195**	1.527	13.835
EDUI	−0.273	5.098	1.548
LNGDPPC	5.541	1.937	0.003
LNURPOP	−10.807*	−4.044*	−15.028*
1st difference			
D(CO_2)	–	−4.643*	51.680*
D(FD)	−2.958*	−3.331*	39.043*
D(KOF)	–	0.014*	54.429*
D(EDUI)	−3.691*	−4.184*	48.601*
D(LNGDPPC)	−3.369*	−2.980*	36.269*
D(LNURPOP)	–	–	–

*, ** show 1% and 5% significance level

Table 5 Kao co-integration test

	t-Statistic	Prob
ADF	1.698629	0.0447
Residual variance	0.010215	
HAC variance	0.011242	

*, ** show 1% and 5% significance level

Table 6 Results of panel quantile regression model

Variables	Q1	Q2	Q3
FD	−0.665*(0.254)	−1.643*(0.596)	−2.141* (0.752)
FD^2	0.269*(0.097)	0.573**(0.227)	0.740**(0.287)
KOF	−0.001(0.003)	−0.011*** (0.007)	−0.033*(0.008)
FD × KOF	0.016*(0.006)	0.041*(0.014)	0.057*(0.017)
FD^2 × KOF	−0.006* (0.002)	−0.014*(0.005)	−0.020*(0.007)
LNURPOP	0.484*(0.061)	0.675*(0.143)	0.850*(0.180)
LNGDPPC	0.370*(0.029)	0.416*(0.067)	0.572*(0.085)
EDUI	−0.052*** (0.030)	−0.040(0.071)	−0.056(0.090)
CONS	−3.629*(0.214)	−3.964*(0.503)	−4.496*(0.635)
Number of obs	217	217	217
Pseudo R2	0.537	0.511	0.588

*, **, *** show the level of significance at 1%, 5%, and 10%, respectively

In Table 5, the KAO co-integration test with the moderating effect of KOF in all SAARC countries has been used to observe the linear relation impact of FD on CO_2 emissions. The null hypothesis is rejected because the ADF values of the Kao test are statistically significant at 5%. It verifies the existence of a long-run link between FD and carbon emissions.

Table 6 presents the panel quantile regression (PQR) outcomes at the lower, middle, and upper quartiles (Q_1, Q_2, and Q_3). The lower values of pseudo R^2 show the goodness of fit by comparing the sum of weighted deviations of this model to the same model with an intercept (Sial et al. 2022). Equation 4 uses the moderating effect of KOF to show the connection between the FD and environmental degradation. At level, the coefficient of the FD index has negative impact on CO_2 emissions (Godil et al. 2021; Ojeyinka & Osinubi, 2022), whereas the quadratic coefficient of the FD index has a positive influence on CO_2 emissions in Q_1, Q_2, and Q_3 (Tahir et al. 2021). The level and quadratic coefficients of the FD index propose a U-shaped relationship (Rani et al. 2022a, 2022b), which means that a higher level of FD in SAARC countries degrades CO2. The moderator variable KOF improves the environmental quality and decreases the CO_2 emissions in Q_2 and Q_3 (Amjad et al. 2021b; Sun et al. 2021; Rahman, 2020). However, Guan et al. (2022) found that KOF decreases CO_2 emissions. At the level, the interaction of FD index and KOF has a positive association with CO_2 emissions; in contrast, the quadratic FD index and KOF interaction negatively influence CO_2 emissions in Q_2 and Q_3 (Mehmood, 2022; Usman et al. 2022). However, Sheraz et al. (2021) found similar results in the linear interaction between FD and KOF in G20 countries.

When we trace this effect by using the mean and standard deviation of KOF and FD, it proposed shifting the turning point of the U-shaped curve as shown in Fig. 4a and b) at Q2 and Q3.This leads us to reject our null hypothesis that the moderation effect of KOF does not change the turning point of the U-shaped curve of the FD and CO_2 emissions in SAARC countries.

By referring Eq. 6, at Q_2, the value of the numerator is negative ($\gamma_1\gamma_5 - \gamma_2\gamma_4 = -0.00049$) which indicates that the turning point is shifted to the left side of the U-shaped curve, while on the other hand, at Q_3, the value of the numerator is positive ($\gamma_1\gamma_5 - \gamma_2\gamma_4 = 0.00064$) which shows the turning point is shifted to the right side of the U-shaped curve. Furthermore, in both Q_2 and Q_3, the value of the coefficient of γ_5 is negative which shows the flattening of the U-shaped curve. The above-mentioned discussion indicates that moderate KOF index improves the FD and declines CO_2 emissions in SAARC countries. Therefore, these countries should import more energy-efficient technologies to reduce CO_2 emissions. Moderate globalization boosts technical innovation by allowing for new carbon-reducing industrial strategies. Global competition among businesses improves product quality, which is also good for the environment. Furthermore, all countries are increasingly intertwined due to globalization, making it easier for financial institutions to fund green projects.

Similarly, the urban population is correlated with an increase in CO_2 emissions. The results suggest that a one percent increase in the urban population deteriorates the environment by 0.484 percent in Q_1, 0.676 percent in Q_2, and 0.85 percent in Q_3. No doubt, an increase in the urban population demands more resources for housing, transport, and medical facilities. Furthermore, it boosts the demand for fossil fuels, which increases the global temperature (Kim et al. 2020; Rahman & Alam, 2021; Yang & Wang, 2020). Economic growth in the SAARC countries also increases CO_2 emissions in all quantile groups. No doubt, resource consumption leads to rapid economic growth but it puts a lot of pressure on the atmosphere (Khan et al. 2021; Usman et al. 2021; Wang et al. 2022a, 2022b). However, education has played a significant role in reducing CO_2 emissions. It is undisputed to claim that the war against climate change cannot be won without encouraging research and development. Information and skill have a crucial role to mitigate environmental degradation (Ahmed & Wang, 2019; Zafar et al. 2020).

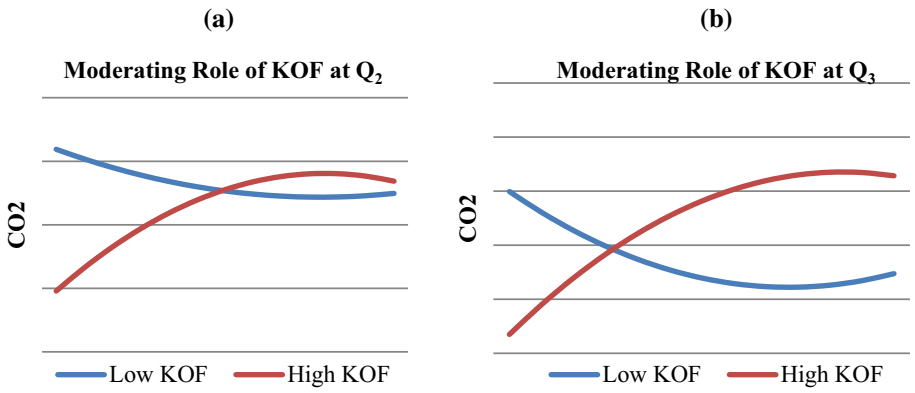

Fig. 4 Tracing the effect between FD and CO_2 with moderating variable KOF

6 Conclusion and policy recommendations

The present study has examined the impact of FD sector on CO_2 emissions in SAARC countries from 1990 to 2020 through utilizing the moderating effect of globalization. The FD index is constructed using four proxies based on financial depth, access, efficiency, and stability. Typically, in developing countries, the FD sector increases CO_2 emissions. However, the moderation effect of globalization (KOF) can decline CO_2 emissions. Long-run coefficients are evaluated by using the panel quantile regression (PQR). The PQR approach estimated the U-shaped relationship between the FD sector and CO2 emissions in SAARC countries (Rani et al. 2022a, 2022b). In order to observe the change in the turning point of the U-shaped relationship, KOF index is used as the moderator. It shifts the turning point before the maturity of the U-shaped curve at the middle quantile group and after the maturity of the U-shaped curve at upped quantile group (for details, see; Abbasi et al. 2022; Green et al. 2021; Adebayo et al. 2021; Baydoun & Aga, 2021). This indicates that we reject the null hypothesis that moderation KOF index does not change the turning point of the U-shaped curve based on FD and CO_2 emissions in SAARC countries. By using energy-efficient technologies, better financial sector interaction with moderate globalization process can enhance environmental condition in SAARC countries. Furthermore, this study also explored that urbanization and GDP per capita increase CO2 emissions. However, education helps in achieving energy efficiency by encouraging research and development and increasing awareness regarding the benefits of a clean environment.

This study recommends that the green finance should be promoted to achieve the sustainable development. For this purpose, the financial institutions must encourage environment friendly investments. The SAARC countries should pay proper attentions to globalization process, because it declines CO_2 emissions. Through globalization, this region can easily control environmental degradation by sharing environmental friendly technologies as these countries are interconnected through boundaries to each other.

The present study suffers from some limitations. This study is based on only SAARC countries. This research work can be extended to developing and developed countries. Furthermore, firm-level data analysis may provide relatively clear picture of the role of FD in reducing CO_2 emissions through green technology innovation. Furthermore, the environmental tax, urbanization, human capital and institutional quality can be used as the moderator in future research.

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