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RESEARCH ARTICLE

Globalization and CO_2 emissions nexus: evidence from the EKC hypothesis in South Asian countries

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Abstract

In the last few decades, developing countries continued to increase their manufacturing industries' phenomenal growth rate. Due to the emergence of globalization, these developing countries are getting economic growth at the cost of environmental pollution. In this context, the extent of linkages between globalization and carbon dioxide (CO_2) emissions has been investigated over the time period of 1972–2013 in South Asian countries. The econometric and graphical analyses are found U-shape association between globalization and CO_2 emissions in Nepal, Afghanistan, Bangladesh, and Sri Lanka, and an inverted U-shape relationship is observed in Pakistan and Bhutan. Moreover, results have shown that there exists a bi-directional causality between globalization and CO_2 emissions in Pakistan, Bangladesh, and Nepal. This indicates that globalization is increasing CO_2 emissions and CO_2 emissions impact globalization by economic growth. However, after some threshold level, globalization is responsible for decreasing CO_2 emissions in Pakistan and Bhutan. For the first time, globalization is incorporated in the economic analysis, showing the U-shape and inverted U-shape associations between globalization and CO_2 emissions. This study suggests some strong policy recommendations to consider globalization as cost-effective tool to achieve sustainable economic growth in South Asian countries.

Keywords Globalization · CO_2 emissions · South Asia · EKC

Introduction

The role of globalization has been greatly acknowledged all over the world in terms of supporting industrial evolution, expansion and ease of doing business, and mitigating migration by enhancing trade at global level. Also, globalization helps developing countries to boost their economic growth by reducing the major problems of poverty, income inequality, and unemployment. The boost in economic growth is ultimately linked with increased energy demand mostly fulfilled by fossil fuels consisting of coal, petroleum, natural gas, etc (Adom 2011). The economic development and industrialization largely based on energy utilization give rise to carbon dioxide (CO_2) emissions. An elevated concentration of CO_2, a strong greenhouse gas and a major climate change indicator, in the earth's atmosphere is harmful environmental feature. The climatic change and environmental degradation, mostly linked to increased CO_2 emissions, significantly contribute to ecological imbalances. As a result of climate variability, the human socio-economic life is badly affected at large (Shahbaz et al. 2015). Owing to the climate variability and increasing temperature linked to elevated CO_2 emissions, the world is facing problems of health risks, rising sea level, deforestation, extremity and change in weather patterns, and loss of biodiversity. These problems have become the challenge to the efforts put by the governments, academics, and policymakers all over the world (Wang et al. 2018).

There exist two popular opinions regarding the association of globalization and CO_2 emissions. Some researchers argue that globalization is responsible for reduction in CO_2 emissions (Christmann and Taylor 2001; Lee et al. 2010; Shahbaz et al. 2015; Lau et al. 2019), while on the other line of

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research, direct association is presented by proposing that globalization would seriously damage the environment if the present energy producing technology remained unchanged (Copeland and Taylor 1994; Friedman 2005; Shahbaz et al., 2017a; Wijen and Tulder, 1994). Moreover, in addition to the economic growth, globalization is also responsible for the decrease in the available natural resources. In this regard, Shahbaz et al. (2019) revealed that developing nations are facing more environmental degradation and pollution compared with 45 years ago.

The industrial economies have shown concerns over the contaminated manufacturing by the developing countries due to environmental damages mostly linked to the economic and industrial growth (Shahbaz et al. 2016). Significant climate variability and serious environmental degradation are reported in developing countries due to open economic policies, weak environmental laws, and their poor implementation (Panayotou 1997; Baek et al. 2009). This implies that globalization is considered a source of pollution concentrated industries especially in developing countries. Therefore, it has become important to find the globalization-CO_2 emissions association in order to find the effect of globalization towards environment impact assessment.

There are a number of studies which discuss the association between globalization and CO_2 emissions. Some of the previous studies report U-shaped and inverted U-shaped association between globalization and CO_2 emissions. The U-shaped association describes that initially globalization will increase environmental quality, but at later stages, environmental quality will start to decline. The inverted-U shaped association indicates that the initial globalization will result in the decreased environmental quality and finally it will start to improve air quality by reducing CO_2 emissions. This study makes an attempt to contribute to the available research in three ways: firstly, the contribution is to use the globalization as a cost-effective tool to reveal its association with CO_2 emissions in South Asian economies. The objective to focus South Asian developing countries lies in the fact that these countries are greatly contributing towards global economy and the ratio of their energy spending and CO_2 emissions is increasing at rapid pace. The second contribution, by following Brown and McDonough (2016), is the use of autoregressive distributed lag (ARDL) approach presented by Pesaran et al. (2001) to find the co-integration amid the estimated equation. The third contribution of our study will be the application of variance decomposition and impulse response function to know the causal affect between globalization and CO_2 emissions for South Asian economies.

After presenting the introduction in the "Introduction" section, the rest of the paper is arranged as follows; background literature is provided in the "Literature review" section. The details of applied methodology and its significance are explained in the "Methodology" section. The econometric results and policy recommendations are discussed in the "Discussion" section 4. The conclusion of the study is presented in the "Conclusion and policy recommendations" section.

Literature review

In the efforts for achieving rapid economic growth, the developing countries have overlooked the issue of environmental quality degradation compromising the ongoing efforts for environmental protection. This situation has led to intense discussion on the environmental cost related to manufacturing activities. As a result, many developing countries are now implementing policies to reduce environmental pollution due to industrial production. Moreover, in the efforts to achieve rapid economic growth, developing countries are also preferring international trade. In this regard, Grossman and Krueger (1991) revealed that international trade can effect environmental pollution positively and negatively in both developing and developed countries.

Similarly, there exist two contrasting views concerning the impact of flexible trade policies on the environment and air quality. The first view is supporting the idea that trade openness provides the countries the opportunities for import and export to obtain comparative advantage. Moreover, trade is also a source to import environment friendly technologies for the production of goods at domestic level. Jayadevappa and Chhatre (2000) argued that trade improves the economic conditions of people and they can, consequently, further invest in green technologies for sustainable economic growth. The second view supports the idea that trade will bring economic prosperity mostly in developing countries but with impact of environmental degradation. This view supports the pollution heaven hypothesis, according to which, developed countries shift their contaminated industries to developing countries to circumvent stringent environmental regulations.

Consequently, developing countries face more environmental pollution (Copeland and Taylor 1994; Christmann and Taylor 2001). Recently, a number of research studies have investigated the function of globalization towards CO_2 emissions in country specific and panel data. These studies included the traditional and modern indicators of globalization. Antweiler et al. (2001) explored that the scale of technological advancement will affect the CO_2 emissions. Moreover, trade can improve air quality if efficient technologies are used for energy production. Copeland and Taylor (1994) also considered the role of strict environmental regulations, by which trade will improve environmental quality. By following the pollution haven hypothesis, they postulated that due to strict environmental regulations, developed countries shift their dirty industries to developing countries (Antweiler et al. 2001). Managi et al. (2009) found that trade will increase CO_2 emissions in a panel of 63 economies during the time span of 1960–1999.

In a survey data, Shin (2004) observed the negative role of trade for environment in some major cities of China. Considering the nature of government policies, McCarney and Adamowicz (2005) showed that trade openness is linked with reduction in air pollution. Similarly, Managi et al. (2009) showed that trade will improve air quality, if the regulations are imposed efficiently. In a same fashion, Jena and Grote (2008) published that trade is reducing CO_2 and NO_2 emissions in some populated cities of India. While attempting the role of globalization for environment, Dinda (2004) validated the Environmental Kuznets Curve (EKC) and pollution haven hypothesis and showed that import and export is improving air quality in developed countries but, on the other hand, polluting air quality in developing countries. For a single country data, Saboori and Sulaiman (2013) held the view that trade openness cannot be considered as a factor of environment in Malaysia, but according to Solarin et al. (2017), Malaysian exports to Singapore are increasing CO_2 emissions.

According to Löschel et al. (2013), trade increases energy intensity, which results into more CO_2 emissions, and these emissions degrade environmental quality in 40 countries. Furthermore, Shahbaz et al. (2012) found the improving role of trade for environment in Pakistan. Shahbaz et al. (2013a) again discussed the negative effects of trade towards air quality in Indonesia. Similarly, Kanjilal and Ghosh (2013) also presented same results in India. But, Tiwari et al. (2013) analyzed that trade is increasing CO_2 emissions in India.

Now it is important to evaluate the available literature, which uses the latest indicators of globalization and its impact on CO_2 emissions. According to Christmann and Taylor (2001), globalization does not affect environmental pollution in China. They confirmed that the Chinese environmental regulations have improved air quality. Lee and Min (2014) analyzed a large panel data of developing and developed world and revealed that globalization reduces air pollution. However, Shahbaz et al. (2015) proved that globalization cannot support the Indian economy and it is responsible for environmental degradation. Later, Shahbaz et al. (2017a) found the supportive role of globalization for Australian economy. Paramati et al. (2017) analyzed the role of political globalization for CO_2 emissions and proved that political globalization is improving environment by reducing CO_2 emissions. Recently, Shahbaz et al. (2017a) investigated the role of sub-indices of globalization (political, economic, and social) towards CO_2 emissions and found that globalization is environmental friendly in Chinese economy.

From the above-mentioned studies, it is clear that recent studies utilize trade openness as an indicator of globalization to find its impact on CO_2 emissions, which shows mixed results. Globalization is advantageous to some countries but not favorable for other countries. Consequently, the available results may not be generalized to some other countries. So we consider the limiting role of trade openness because it covers only trade intensity (M, Shahbaz, 2019). In this regard, the globalization index by Dreher (2006) might be suitable because it covers political globalization, social globalization, and economic globalization while investigating its role towards CO_2 emissions. So this study investigates the role of globalization, following Dreher (2006), towards CO_2 emissions for South Asian countries.

Methodology

The key research focus of this study is to find the globalization-CO_2 emissions nexus in terms of EKC for South Asian countries using data obtained during 1972–2013. Managi et al., 2009; Baek et al., 2009; Löschel et al., 2013; Naughton, 2014; Shahbaz et al., 2015; and Paramati et al., 2017 have investigated the connection between globalization and CO_2 emissions. Most of their findings were inconclusive regarding the EKC between globalization and CO_2 emissions, whereas this study presents another method to find the U-shape or inverted U-shape associations between the two variables by following the carbon emissions function as under:

$$CO_t = f(GL_t) \quad (1)$$

For log linear specification, annual data has been transformed into natural logarithmic form for efficient representation of results.

Further, empirical equation is given as:

$$lnCO_t = \alpha_0 + \alpha_G lnGL_t + \mu_i \quad (2)$$

In above equation, CO_t, GL_t, and μ_i represent the logarithmic form of CO_2 emissions, globalization, and error term correspondingly. Different studies applied traditional co-integration approaches including Engle and Granger, 1987; Johansen and Juselius, 2009; and Stock and Watson, 1993. However, these co-integration approaches are not suitable for small data having mixed order of integration between estimated time series. Moreover, these techniques can mislead the environmental policymakers by giving less robust results. Therefore, we have selected the ARDL approach to test the association amid the variables. The unrestricted error correction model (UECM) for co-integration approach is formulated as:

$$\begin{aligned}\Delta lnCO_t = {} & \alpha_1 + \alpha_t T + \alpha_2 lnCO_{t-1} + \alpha_3 lnGL_{t-1} \\ & + \sum_{i=1}^{n} \acute{\alpha}_1 \Delta lnCO_{t-i} + \sum_{i=0}^{n} \acute{\alpha}_2 \Delta lnGL_{t-i} \\ & + \mu_i\end{aligned} \quad (3)$$

where Δ is term of difference; α_1, α_2, and α_3 show long-run associations; and $\acute{\alpha}_1$, and $\acute{\alpha}_2$ represent short-run relationships.

Table 1 Descriptive statistics

Variable	Statistics	Pakistan	India	Bangladesh	Sri Lanka	Afghanistan	Bhutan	Nepal
Globalization	Mean	3.7319	3.7039	3.4531	3.7882	3.2105	3.2420	3.3381
	Median	3.7203	3.5584	3.4703	3.7531	3.1579	3.1714	3.4040
	Maximum	4.0043	4.1246	3.9311	4.1185	3.6637	3.6064	3.8170
	Minimum	3.4688	3.4224	2.9237	3.3748	2.9719	3.1161	2.7643
	Std.Dev	0.1866	0.2596	0.3160	0.2352	0.1929	0.1542	0.3241
	Skewness	0.2164	0.5025	− 0.0757	− 0.1439	1.2526	1.2481	− 0.2480
	Kurtosis	1.4809	1.5886	1.7727	1.8877	3.3760	3.0102	1.8767
	Jarque-Bera	4.3663	5.2541	2.6714	2.3099	11.2318	10.9053	2.6386
	Probability	0.1126	0.0722	0.2629	0.3150	0.0036	0.0042	0.2673
CO_2 emissions	Mean	− 0.5040	− 0.3038	− 1.8130	− 1.0167	− 2.0567	− 1.6316	− 2.7143
	Median	− 0.4235	− 0.2554	− 1.8262	− 1.1932	− 1.8679	− 0.9736	− 2.6634
	Maximum	− 0.0054	0.4666	− 0.7845	− 0.2300	− 0.8866	0.1850	− 1.4389
	Minimum	− 1.175	− 0.9810	− 2.9436	− 1.5871	− 3.2569	− 4.5907	− 3.8761
	Std.Dev	0.3699	0.4442	0.5960	0.4559	0.6912	1.4849	0.7178
	Skewness	− 0.4141	0.0329	0.0335	0.3547	− 0.2946	− 0.8123	0.0076
	Kurtosis	1.864	1.8158	1.9444	1.5634	1.8689	2.3606	1.7154
	Jarque-Bera	3.458	2.4613	1.9577	4.4925	2.8424	5.3347	2.8880
	Probability	0.1774	0.2920	0.3757	0.1057	0.2414	0.0694	0.2359

To compute the co-integration between variables, bound testing approach is used. In this test, the F statistics confirm the joint co-integration among the variables. The long-run association between the variables is acceptable, if F-stat value is more than the upper bound value. However, the long-run association cannot be accepted if the F-stat value is less than the value of lower bound. Further, diagnostic tests have been applied to check the absence of serial correlation and white heteroskedasticity. Also, the stability of ARDL model is confirmed by CUSUM and CUSUMSQ tests.

This study uses annual data of per capita CO_2 emissions (metric tons) obtained from the World Development Indicators. An overall globalization data provided by Dreher (2006) is appropriate for South Asian countries. Dreher (2006) divided the whole globalization index into three subcategories, viz., political globalization, economic globalization, and social

Table 2 Unit root test

Country	Variable	Unit root at level		Unit root at 1st difference	
		T statistics	Break year	*T* statistics	Break year
Pakistan	$lnCO_t$	− 2.2429 (0.95)	1984	− 8.3453*** (0.00)	2007
	$lnGL_t$	− 4.0004 (0.15)	1988	− 7.9024*** (0.00)	1989
India	$lnCO_t$	− 0.8039 (0.99)	1984	− 6.1663*** (0.00)	2002
	$lnGL_t$	− 3.9225 (0.18)	1993	− 4.9954*** (0.00)	1987
Bangladesh	$lnCO_t$	− 1.0710 (0.33)	2001	− 6.5324*** (0.00)	2007
	$lnGL_t$	− 1.7673 (0.72)	1985	− 7.6069*** (0.00)	1988
Afghanistan	$lnCO_t$	− 3.9757 (0.11)	1998	− 4.8129** (0.08)	2004
	$lnGL_t$	− 2.4126 (0.12)	2004	− 9.8699*** (0.00)	2005
Nepal	$lnCO_t$	− 28,166 (0.15)	1990	− 7.6082*** (0.00)	1990
	$lnGL_t$	− 2.9391 (0.90)	1984	− 8.1075*** (0.00)	1985
Bhutan	$lnCO_t$	− 2.7446 (0.43)	2010	− 7.5926*** (0.00)	1989
	$lnGL_t$	− 2.3659 (0.96)	2003	− 8.9828*** (0.00)	1998
Sri Lanka	$lnCO_t$	− 4.3290* (0.09)	1996	− 5.9819*** (0.00)	2006
	$lnGL_t$	− 2.7600 (0.54)	1991	− 5.5977*** (0.00)	2000

***, **, and * show the significance at 1%, 5%, and 19%, respectively

Table 3 Bound statistics

Countries	Pakistan	India	Bangladesh	Afghanistan	Nepal	Bhutan	Sri Lanka
Lag length	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Break year	1984	1984	2001	1998	1990	2010	1996
F-stats	11.8905*** (0.00)	31.6957*** (0.00)	4.8116** (0.08)	4.4509 (0.56)	3.9954 (0.25)	5.1382*** (0.00)	4.2229 (0.32)
R^2	0.9897	0.9958	0.9927	0.9482	0.9374	0.9678	0.9653
Adj-R^2	0.9894	0.9956	0.9923	0.9406	0.9324	0.9670	0.9625
D.W test	2.0492	1.8320	1.8196	2.1391	1.7921	2.1615	2.1944
Diagnostic tests							
X^2 NORMAL	1.0245	0.7732	0.6696	2.2884	1.1916	0.1949	3.0395
X^2 SERIAL	0.2160	0.9537	0.8849	0.4906	0.6647	1.0025	0.4191
X^2 ARCH	0.4938	0.1393	0.4924	0.7893	0.2966	1.6901	0.0912
X^2 WHITE	0.8181	5.3758	0.2667	0.5497	1.1074	2.3844	1.6097
X^2RAMSAY	1.7749	0.4910	0.1293	2.7836	1.9971	1.1135	0.3409
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMsq	Stable	Stable	Stable	Stable	Stable	Stable	Stable

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

6.84, 7.84 1%; 4.94, 5.74 5%; 4.04, 4, 78 10%

globalization. The political globalization index consists of number of memberships of international organizations. The social globalization comprises of tourism, telephone calls, and data on internet usage, and the economic globalization mainly consists of foreign direct investment, trade, and taxes on trade.

Table 1 shows the descriptive statistics where it is evident that globalization is normally distributed in all the countries except Bangladesh. The data of CO_2 emissions is also normally distributed in all the countries except Sri Lanka and Bangladesh. The data of Bhutan and Sri Lanka is of capricious nature.

For the validity of co-integration test, it is essential to perform unit root test. Unit root test indicates the order of integration of the variables, which should not be of I(2). Bound testing approach can give spurious results if any variable is of I(2) (Shahbaz et al. 2018). To test stationarity of globalization and CO_2 emissions, ADF test has been performed. Table 2 is showing the results of unit root test.

Discussion

While examining the unit root test results, it can be seen from Table 2 that both variables are facing the problem of unit root at level, but at first difference, both variables are stationary with structural breaks. These structural breaks may be attributed to implementations of trade and environmental regulations in South Asian countries. The subsequent step is to analyze the co-integration in the time series for the period of 1972–2013.

The bound statistics are presented in Table 3, which show that the value of F statistics is higher than upper critical value for the data of India (1%), Pakistan (1%), Bangladesh (10%), and Bhutan (1%), when our dependent variable is carbon emissions. Resultantly, the null hypothesis can be rejected for no co-integration, indicating that both variables are co-integrated in the long run. But for Afghanistan, Nepal, and Sri Lanka, the null hypothesis can be accepted for no co-integration because the computed F statistics is lower than the upper bound statistics. This implies that there exists a neutral connection between globalization and CO_2 emissions

Table 4 Short-run and long-run results

Country	Long run	Short run	
	GL_t	ΔGL_t	ECM_{t-1}
Pakistan	− 0.0256 (0.68) (−0.4103)	0.5173**(0.08) (1.7674)	− 0.0421***(0.00) (− 2.7298)
India	− 7.4947 (0.89) (− 0.1302)	0.0095*** (0.00) (6.7081)	0.0012 (0.89) (0.1288)
Bangladesh	1.8299*** (0.00) (29.3593)	0.7583*** (0.00) (4.2302)	− 0.4143*** (0.00) (− 4.3300)
Afghanistan	7.8683*** (0.00) (3.6232)	2.4235*** (0.00) (33755)	− 0.1745*** (0.00) (− 2.7652)
Nepal	2.1520*** (0.00) (8.554)	0.4147 (0.13) (1.0316)	− 0.3647*** (0.00) (− 2.8185)
Bhutan	0.2709 (0.11) (0.4954)	0.0120 (0.15) (0.6534)	− 0.0444 (0.23) (− 1.6488)
Sri Lanka	2.3730*** (0.00) (5.2687)	1.1576*** (0.00) (2.5682)	− 0.1735*** (0.00) (− 2.2904)

in these countries. The long-run and short-run relationships are shown in Table 4. It can be noted that globalization is responsible for increasing CO_2 emissions at 1%, 5%, and 10%, respectively. This means that 1% increase in the rate of globalization will increase CO_2 emissions by 1.8299% in Bangladesh, 7.8683% in Afghanistan, 2.1520% in Nepal, 0.2709% in Bhutan, and 2.3730% in Sri Lanka. For Pakistan and India, 1% increase in globalization will reduce CO_2 emissions by 0.0256 and 7.4947, respectively. These results are in agreement with Shahbaz et al. (2013b), who found that air quality is improving with globalization in Turkish economy. While in the short run, globalization is significantly increasing CO_2 emissions in Pakistan, India, Bangladesh, Afghanistan, and Sri Lanka. For Bhutan and Nepal, the globalization is increasing CO_2 emissions but insignificantly. In a similar way, short-run results can be compared with long-run results. According to Narayan and Narayan (2010), if short-run value is less than the long-run value, then the globalization is increasing CO_2 emissions, indicating that there exists U-shape relationship between globalization and CO_2 emissions. Nevertheless, if the short-run value is more than the long-run value, globalization is decreasing CO_2 emissions, representing the existence of EKC with inverted U-shape association between the variables. In this regard, the estimation shows that short-run value is more than the long-run value in Pakistan and India, means that globalization increases CO_2 emissions initially, but after certain level of economic growth, the level of CO_2 emissions will start to decline. Note that the short-run value is less than the long-run value in Afghanistan, Bangladesh, Nepal, and Sri Lanka, means that globalization increases CO_2 emissions in the long run and shows a U-shape relationship. This trend may be the result of inadequate and poor technologies adopted for industrial production in these developing countries (Figs. 1, 2, 3 and 4).

According to Brown and McDonough (2016) the comparison of short-run and long-run relationships will not provide

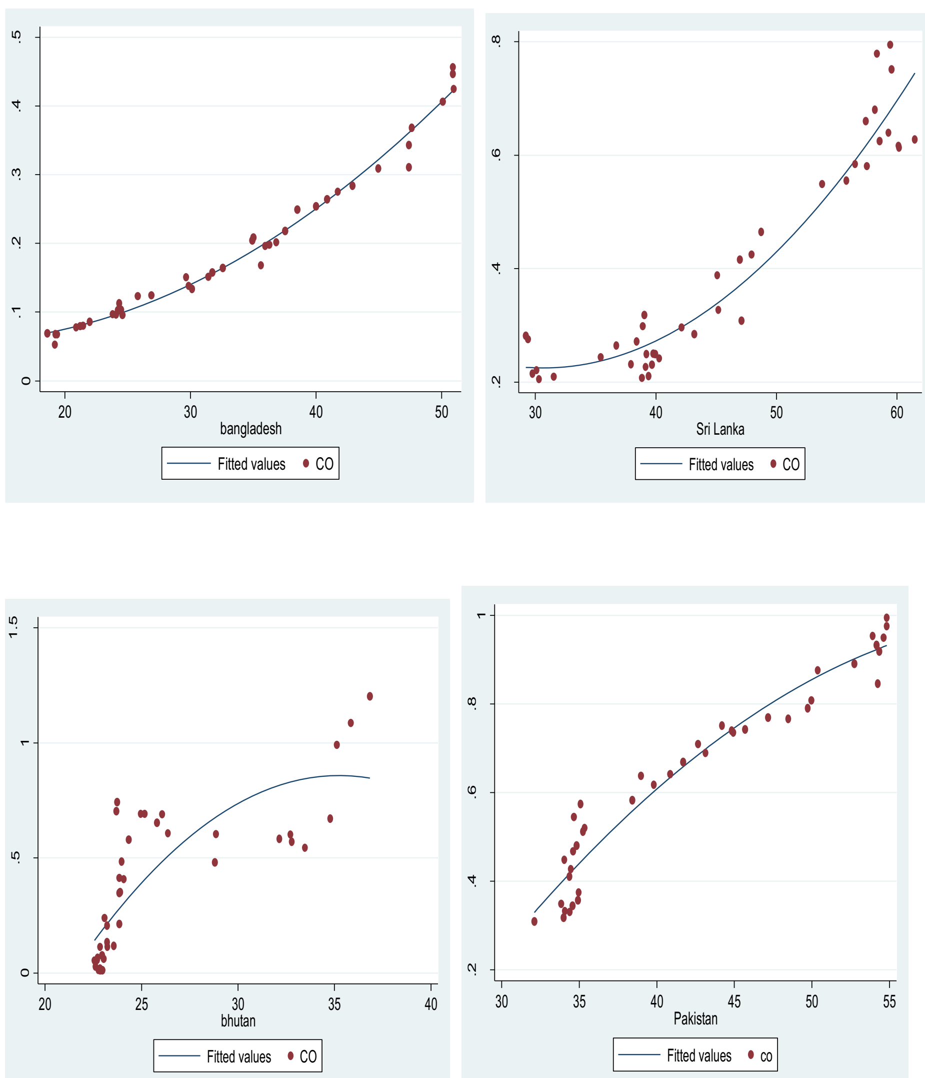

Fig. 1 U-shape and inverted U-shape associations

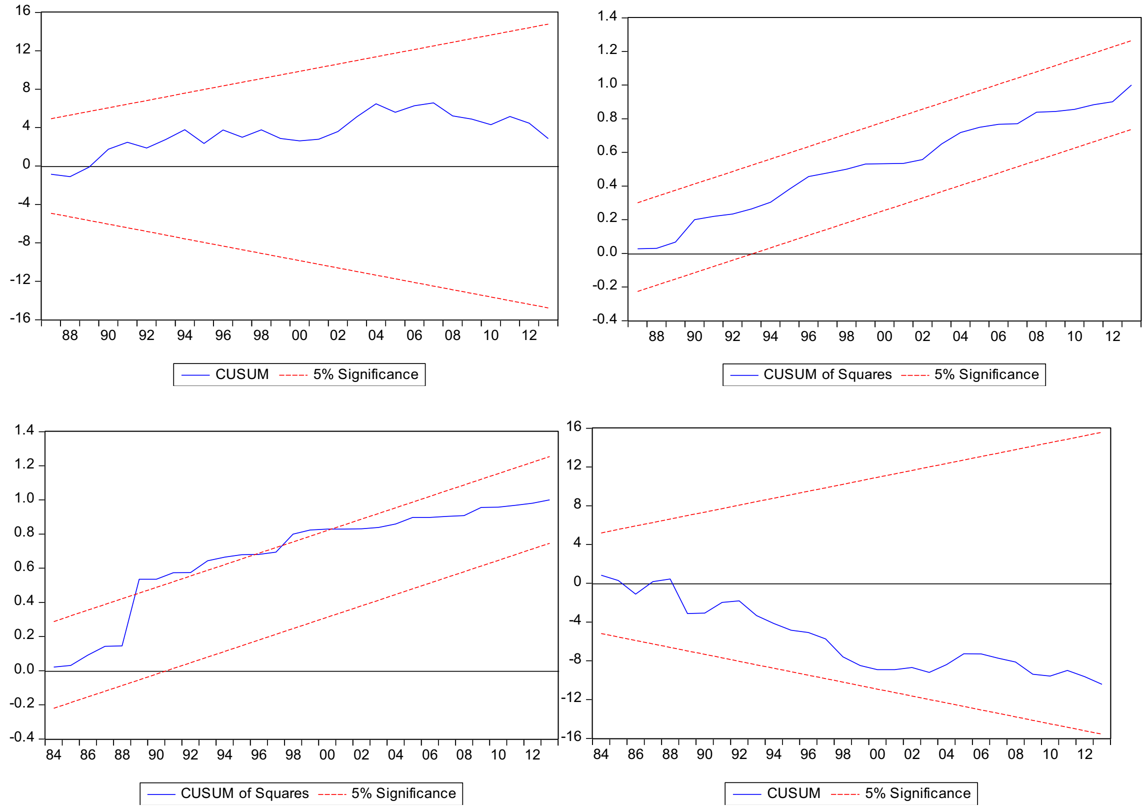

Fig. 2 Recursive Pakistan

conclusive results. Moreover, they argued that the slope of EKC will be in upward range if the long-run elasticity is more than short-run elasticity. But if the short-run elasticity is more than the long-run elasticity, the slope of EKC will be in downward range. Note that association between globalization and CO_2 emissions is a long-run incident. In this regard, it can be argued that the evaluation of short-run and long-run associations can give the information about EKC. Moreover, it can also be assumed that the error correction model (ECM) can give invalid information about EKC. The ECM provides information about the speed of adjustment from short-run to long-run path but does not provide any information about the turning point of the association between globalization and CO_2 emissions. The turning point, importantly, will tell the role of globalization towards CO_2 emissions, either it will be increasing or reducing CO_2 emissions. Therefore, the quadratic function of CO_2 for EKC is long-run phenomena. Consequently, by following (Brown and McDonough 2016) and applying quadratic carbon emission function, the occurrence of EKC between globalization and CO_2 emissions is revealed.

We follow Brown and McDonough (2016) and include the quadratic function of CO_2 emissions to find the U-shape or inverted U-shape association between globalization and CO_2 emissions. In this process, square term of globalization is taken. Table 5 shows the results of square of globalization and CO_2 emissions nexus. Note that there exist inverted U-shape associations for Pakistan and Bhutan, indicating that 1% increase in globalization will lower 8.2052% CO_2 emissions in Pakistan in the future. Globalization will stimulate CO_2 emissions at initial stage, but later it will start to improve air quality for these countries. Moreover, it is evident from the analysis that globalization is environmental friendly and can be used as an economic tool to reduce CO_2 emissions in Pakistan and Bhutan. These findings are consistent with the findings of Shahbaz et al. (2015) and Shahbaz et al. (2017a). It can be noted that in Bangladesh and Sri Lanka, globalization is increasing air pollution, and the relationship is U-shape, which means initially, globalization will improve air quality, but in later stages, the air quality will start to deteriorate. This can be due to the implementation of flexible environmental laws in Sri Lanka and Bangladesh.

The CUSUM and CUSUMSQ tests for Pakistan are stable at 5% level, but in Bhutan, the diagram of CUSUMSQ test shows that critical value exceeds the upper critical bounds, which may be mainly due to the political crises in Bhutan during 1990. The political crises affect the economic activity, which further disturb the air quality as seen in Bhutan. Therefore, it can be concluded that an overall estimation for Bhutan is reliable and stable. Innovative accounting approach (IAA) has also been applied to find direction of causality because granger causality test cannot find causal affect within

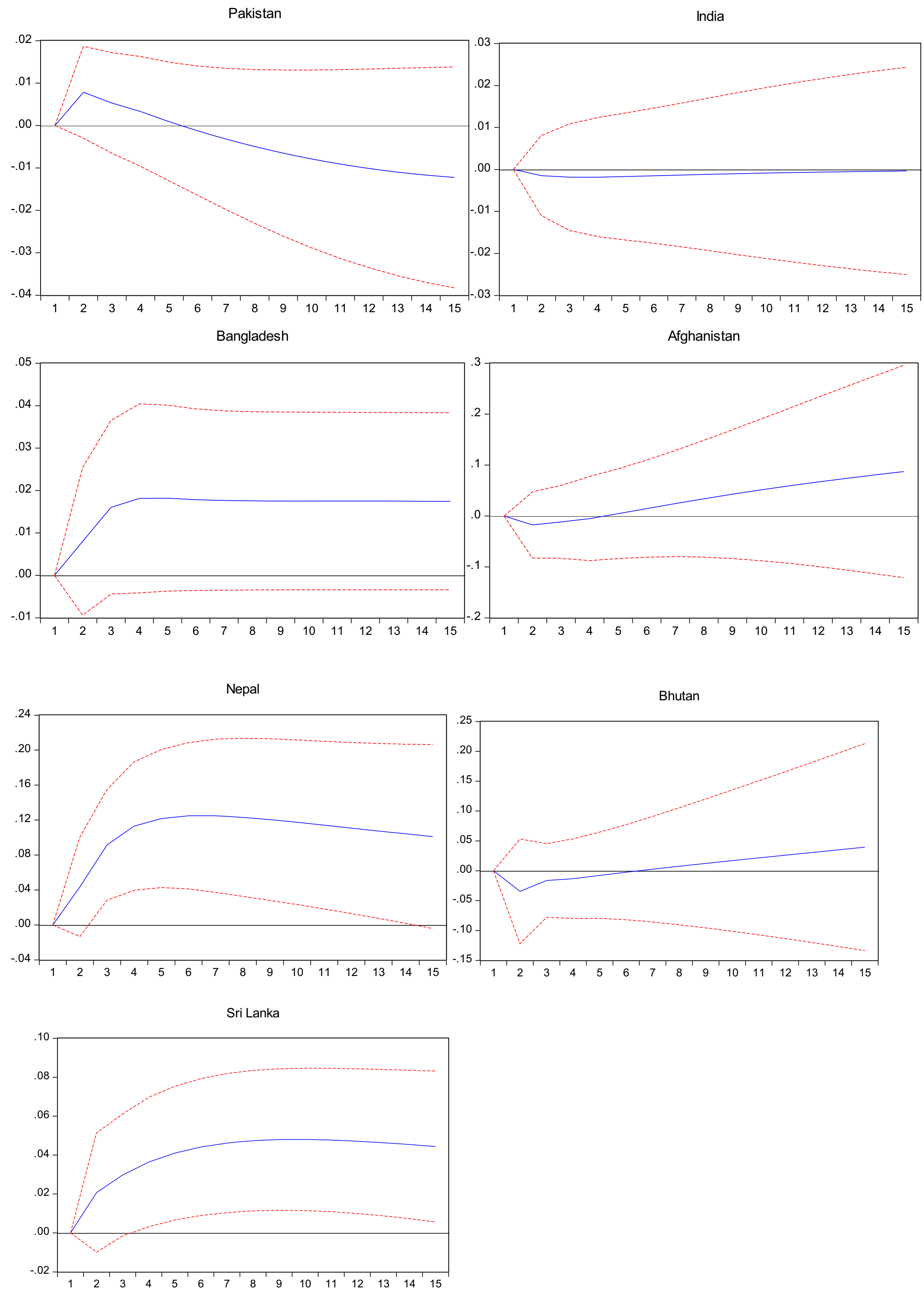

Fig. 3 Impulse response function of $\ln CO_2$ to lnGL

sample period. Therefore, innovative accounting approach is suitable to find causality ahead of sample duration. IAA approach consists of variance decomposition analysis and impulse response function. According to ("Pesaran and Shin

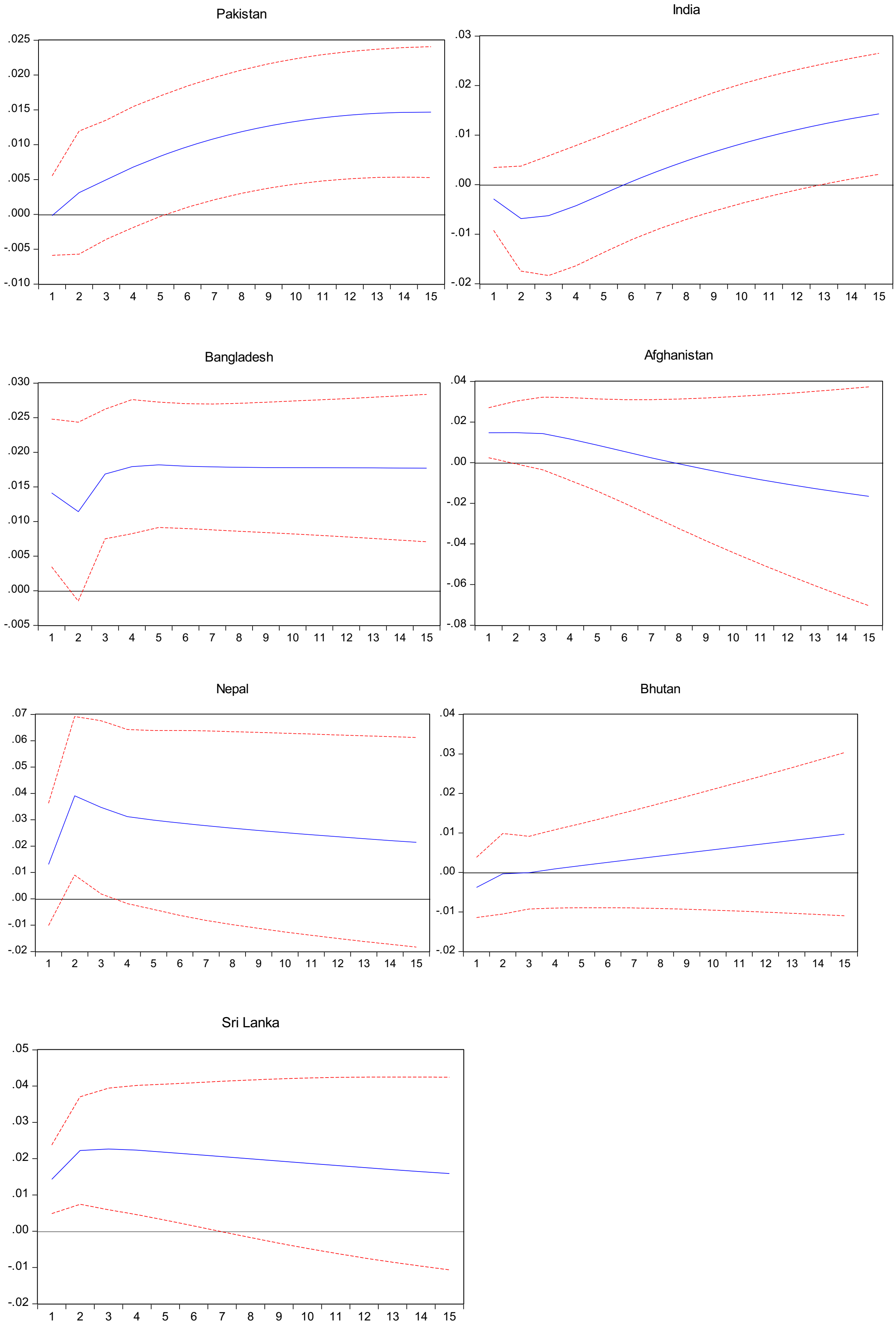

Fig. 4 Fig. 3: impulse response function of lnGL to $lnCO_2$

Table 5 EKC

Dependent variable is CO_t

Variable	Pakistan	India	Bangladesh	Afghanistan	Nepal	Bhutan	Sri Lanka
GL_t	23.4277 (0.52)	− 2.5565 (0.33)	− 1.0143 (0.23)	− 150.7162 (0.33)	− 3.8116*** (0.00)	− 199.6863*** (0.00)	− 2.8361*** (0.00)
GL_t^2	− 8.2052 (0.54)	0.4376 (0.28)	0.4228*** (0.00)	22.0759 (0.87)	0.8990*** (0.00)	28.5388*** (0.00)	0.6770*** (0.00)
R^2	0.9919	0.9968	0.9955	0.9526	0.9392	0.9793	0.9655
F statistics	6.5570*** (0.00)	20.6255*** (0.00)	6.005*** (0.00)	1.0043 (0.97)	4.7640*** (0.00)	7.5202*** (0.00)	3.0740 (0.75)
D.W test	1.9267	1.9773	2.3272	2.1490	1.8812	1.8756	2.1459
Diagnostic tests							
X^2 NORMAL	0.8411	0.0529	0.1506	1.3311	0.7144	0.7419	2.3341
X^2 SERIAL	0.9629	0.2147	0.0127	2.0494	0.4250	0.2719	0.2972
X^2 ARCH	0.1813	0.9904	0.0563	0.8093	0.3690	0.0364	0.0778
X^2 WHITE	0.4375	3.7634	0.7817	0.2393	0.7850	0.5358	3.2578
X^2RAMSAY	3.1638	1.5900	0.4052	1.6972	0.5607	6.4775	0.1658

Probability values are in parenthesis

(1999) the effect of one variable to the other can be determined by variance decomposition. The innovative shocks of one variable and its proportional contribution to the other variable can be revealed by decomposition analysis. Shahbaz (2019) argued that variance decomposition analysis in VAR framework can provide reliable results. The results of variance decomposition analysis are presented in Table 6.

Table 6 shows that innovative shock originates from globalization (GL) that affect CO_2 emissions by 17.83%, 16.53%, and 70.99% in Pakistan, Bangladesh, and Nepal, respectively. In India, Afghanistan, Bhutan, and Sri Lanka, globalization affects CO_2 emissions by 2.82%, 1.63%, 5.99%, and 3.49%, respectively. In distinction, the innovative shock originates from CO_2 emissions that explain globalization by 62.68%, 78.36%, 40.91%, 78.39%, 91.47%, 94.91%, and 24.73% in Pakistan, India, Bangladesh, Afghanistan, Nepal, Bhutan, and Sri Lanka, respectively. These results show that there exists bi-directional causality between globalization and CO_2 emissions in Pakistan, Bangladesh, and Nepal which means globalization is increasing CO_2 emissions and CO_2 emissions affect globalization by economic growth. But after some threshold level, globalization is decreasing CO_2 emissions in Pakistan and Bhutan. These findings are similar as (Shahbaz et al. 2017b), which found the role of globalization in decreasing air pollution in China. However, globalization is increasing CO_2 emissions in Bangladesh. This finding is in line with Shahbaz, (2019). Similarly, CO_2 emissions are causing globalization in Pakistan, India, Bangladesh, Afghanistan, Nepal, Bhutan, and Sri Lanka, respectively.

After discussing the variance decomposition results, next step is to discuss impulse response function. This test shows the reaction of dependent variable after the shocks in independent variable. Note that the response of CO_2 emissions is positive, means that globalization is increasing CO_2 emissions in Bangladesh, Bhutan, Nepal, and Sri Lanka. The response of CO_2 emissions is negative owing to the forecast errors originate by globalization in Pakistan. Globalization responds positively as results of forecast errors from CO_2 emissions in Bhutan, Pakistan, India, and Bangladesh. But globalization responds negatively due to the shocks from CO_2 emissions in Sri Lanka, Nepal, and Afghanistan.

Conclusion and policy recommendations

A sound literature is available regarding the relationship between CO_2 emissions and GDP. Many studies have investigated the EKC by incorporating the square term of GDP, but very few studies available, which investigated the globalization-CO_2 emission nexus. Globalization and CO_2 emissions nexus is currently a well-debated research area and need further careful consideration. Nevertheless, to the best of our knowledge, no study has been conducted to find the globalization-CO_2 emissions nexus for South Asian countries. This study investigated the EKC hypothesis over the annual data of 1972–2013 in South Asian countries. In the analyses of the data, if short-run elasticity is less than the long-run elasticity, then the globalization is responsible for increase in CO_2 emissions, means that there exists U-shape relationship between globalization and CO_2 emissions. Nevertheless, if the short-run elasticity is more than the long-run elasticity, globalization negatively related to CO_2 emissions, indicating the existence of EKC with inverted U-shape association between the variables. Applied unit root and co-integration tests have been followed (Brown and McDonough 2016) to re-investigate

Table 6 Variance decomposition analysis

Time span	Variance decomposition of $lnCO_t$						
	Pakistan	India	Bangladesh	Afghanistan	Nepal	Bhutan	Sri Lanka
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	5.145698	0.024752	1.264094	0.000254	5.083784	0.686447	0.478709
3	6.915874	0.901649	4.241296	0.460054	14.4336	2.519034	0.496902
4	8.915911	1.637831	7.501252	0.609574	27.02097	2.976898	0.654255
5	9.851124	2.210521	9.790461	0.933469	37.66469	3.225028	0.882817
6	10.95914	2.613769	11.31228	1.123015	45.33507	3.605043	1.147962
7	11.84505	2.892409	12.40588	1.322611	51.06253	3.947737	1.433046
8	12.74905	3.053971	13.25961	1.451427	55.53727	4.218026	1.723005
9	13.55931	3.129135	13.96367	1.547895	59.09384	4.482108	2.010121
10	14.35297	3.142829	14.56111	1.596377	61.98168	4.746613	2.289449
11	15.10036	3.11482	15.07369	1.614265	64.38523	5.001505	2.557888
12	15.82516	3.059635	15.51612	1.612412	66.42014	5.251091	2.813632
13	16.51819	2.987951	15.90082	1.607191	68.16364	5.50024	3.055745
14	17.18755	2.907242	16.23824	1.611499	69.67421	5.74907	3.283906
15	17.83087	2.822594	16.53666	1.63103	70.99618	5.997801	3.498211
Variance decomposition of $lnGL_t$							
1	98.77846	98.82898	84.09855	88.77543	98.94572	97.54577	80.30347
2	92.31512	96.49105	83.72623	86.95314	91.31627	98.58023	67.41122
3	89.10651	94.88579	82.52194	83.27852	91.97849	98.07475	54.0332
4	85.37432	94.84572	73.79956	82.7517	92.76451	98.41619	47.0994
5	82.45205	95.35188	65.44538	83.19288	92.6226	98.73298	42.51513
6	79.52232	95.92862	60.19869	84.67509	92.21478	98.90759	39.12935
7	76.93030	96.28585	56.29459	86.44029	92.04805	98.95925	36.43852
8	74.48799	96.18610	53.14324	87.85269	91.96018	98.85322	34.1963
9	72.29713	95.45843	50.55595	88.54757	91.85154	98.60908	32.28159
10	70.28759	94.01254	48.35593	88.20549	91.75134	98.24562	30.61929
11	68.47075	91.84851	46.4501	86.96247	91.67746	97.76624	29.15891
12	66.81316	89.04927	44.7921	85.01627	91.61747	97.18019	27.86418
13	65.30788	85.75733	43.34057	82.75304	91.56328	96.50208	26.70784
14	63.93526	82.14192	42.05924	80.46341	91.51538	95.74333	25.66879
15	62.68438	78.36868	40.91975	78.39626	91.47391	94.91413	24.73028

the EKC by incorporating the squared term of globalization in CO_2 emissions function. Note that by comparing the short-run and long-run elasticities, it is found that long-run elasticity is more than the short-run elasticity, which means that globalization is increasing CO_2 emissions in Bangladesh, Afghanistan, Nepal, and Sri Lanka. This shows the U-shape relationship between globalization and CO_2 emissions. After using the quadratic CO_2 emission function, the presence of EKC is found in Pakistan, but the relationship is U-shape in other South Asian countries (Bangladesh, Nepal, Afghanistan, Bhutan, India, and Sri Lanka). The U-shape association shows that these countries should direct their policies on globalization to achieve sustainable development. In this manner, efficient energy resources should be encouraged to achieve economic objectives. Renewable energy resources like solar, wind, and geothermal should be utilized for sustainable economic growth. Governments of these countries should encourage the foreign investors to invest in energy sector for efficient energy generation. Moreover, governments should introduce investment incentives to attract the foreign investors. Additionally, energy-related research should be funded to bring innovation in energy production technologies. As noted that an inverted U-shape relationship is found between globalization and CO_2 emissions in Pakistan, which indicates that Pakistan should greatly focus on renewable energy resources for sustainable growth and to achieve improved air quality. In this regard, Pakistan should produce energy from hydro, wind, and solar energy. Moreover, Pakistan needs to introduce strict implementation of environmental laws to reduce the atmospheric concentration of CO_2. Environmental policymakers should use the globalization as an economic tool to reduce environmental pollution in South Asia. Future research can be conducted by incorporating the economic and non-economic factors in the globalization-CO_2 emissions nexus in South Asian countries.

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