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Do economic endeavors complement sustainability goals in the emerging economies of South and Southeast Asia?

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Abstract

Purpose – In the present study, the authors intended to investigate whether the economic growth drivers such as per capita income, financial development, nonrenewable energy solutions and trade expansion have invigorated the level of environmental pollution in the eight developing nations of South and Southeast Asia.
Design/methodology/approach – Considering the possibility of the cross-sectional dependency, the authors employed relatively new econometric approaches, that is, the Westerlund cointegration test and cross-sectional augmented distributed lag mean estimation (CS-DL) for the period of 1990–2015.
Findings – The simulation results of the study confirmed an *N*-shaped environmental Kuznets curve, which raised a question on the existing economic policies in these nations. Further, the study reported that the improvements in the financial sector, nonrenewable energy consumption and trade expansion contributed to increasing the level of CO_2 emissions in the long run.
Originality/value – Based on the results, the authors intended to provide a unique policy framework because the present policies are generating a trade-off between economic and environmental goals. If the suggested framework is employed across sectors, the given countries may likely achieve the sustainable development goals by 2030.

Keywords CO_2 emissions, Financial development, Nonrenewable energy resources, South and Southeast Asian countries, CS-DL
Paper type Research paper

1. Introduction

The changing pattern of industrialization around the globe is triggering the course of economic growth to make an exodus from sustainability, and this concern is the primary emphasis of the Sustainable Development Goals (SDGs) 2018 report (United Nations, 2018a). In accordance with this report, nations are encountering complications in realizing the commitments of SDG 13, that is, the climate action, and industrial growth pattern has been acknowledged as a primary cause behind this quandary. While bringing about this feat of elevated growth, the cross-border transaction of resources had been assuaged steadily, and plausibility of this assuaging has been ascertained by improvement in trade relations, which is in turn reflected in the volume of international trade. As international trade directly stimulates the production process, it bears ecological concerns. International trade fuels the

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worldwide demand and supply considerations through the exchange of products and services, and consequently, production procedures are impacted. Now, with a view to endure the competition in the international market, nations deliberate on being cost-effective, and in this journey, corporations continue making use of fossil-fuel-based solutions that wane environmental quality (Shahbaz *et al.*, 2013). Evolution along this path of economic expansion turns out to be challenging for the nations to appreciate the resolutions of SDG 7, that is, clean and inexpensive power, and noncompliance to these resolutions might subsequently induce the exodus from realizing the resolutions of SDG 8, that is, decent work and economic growth. In such a scenario, a surge in trade volume might bring about a severe peril to the foundation of sustainable development in emerging economies (see Figure A1).

In the context of international trade, discussion on the utilization of resources calls for special reference to natural resource extraction and financial mobilization in the Asian countries. Natural resource holds a crucial part in the economic revolution of these nations, by supporting the industrial expansion. A part of analogous importance in industrial development is also portrayed by financial mobilization (Bekhet *et al.*, 2017). On the one hand, both of these events are accountable for the stratum of economic growth attained by the Asian countries, on the other hand, these events are also accountable for the waning of environmental quality in these nations. The latest reports published by United Nations (2018b) outline that these nations are stumbling upon realizing the resolutions of SDG 13, and a major reason behind this phenomenon is accredited to the stature of financial mobilization toward the discovery of alternate energy solutions and improper utilization of natural resources. Although they have adequately proceeded on the facade of diminishing inequalities, prevailing financial mobilization toward improvements in energy consumption patterns might generate interference in the approach toward accomplishing the SDGs by 2030.

In terms of economic growth, international trade and financial mobilization gave substantial support to the South and Southeast Asian countries. As per the report of OECD (2018), the South and Southeast Asian regions are likely to experience an annual growth rate of more than 5% by 2023. However, these growth endeavors have put forth serious pressure on the environmental quality of these nations, and owing to this phenomenon, these countries might encounter difficulties in realizing the resolutions of SDG 13. Now, with the rise in industrial development in these nations, the vocational opportunities created in the industrial sector have been characterized to be labor-intensive, and these jobs have created a rural—urban migration. Owing to this labor migration, the urban infrastructure of the South and Southeast Asian countries is facing pressure, and this rise in population in the urban centers is leading toward more extraction of natural resources to commensurate the rising demand for energy. Therefore, the rise in population in these urban centers might lead to rapid environmental degradation. The financial mobilization in these nations is not being directed toward the urban infrastructural development, which has been identified by Bhaskaran (2018), on behalf of the International Monetary Fund (IMF). In this perspective, a policy-level gap exists in aligning the environmental and economic policies to address the issues of climate change.

Given this background, it can be anticipated that an inclusive policy framework is necessitated for the South and Southeast Asian economies, so that these economies can make progress toward accomplishing the SDG resolutions by 2030. In this quest, the present study focuses on evaluating the impact of economic growth pattern, trade openness, extraction of natural resources and financial mobilization on carbon emissions in the South and Southeast Asian economies over the period of 1990–2015. Through this exploration, the present research intends to suggest a comprehensive policy structure for realizing sustainable development and successively attuning concomitant economic and developmental policies. As these nations are characterized as the laggards in realizing the SDGs, hence, devising policy outlines for these nations is anticipated to help other emerging economies to standardize their policies for ascertaining sustainable development. Consideration of economic growth, trade openness, financial mobilization, extraction of natural resources and environmental degradation within a unified policy plan might succor in suggesting a broad policy framework for attaining SDG 7, SDG 11, SDG 13 and consequently, SDG 8.

While talking about the policy-level contribution, it needs to be remembered that a policy outline by taking transactional spillovers and structural similarities within nations into account necessitates an appropriate analytical approach. To appraise the effect of policy parameters on the target policy variable, while pondering upon transactional spillovers and structural similarities, demands the examination to be accomplished following the second-generation approach. In this pursuit, the cross-sectional augmented distributed lag (CS-DL) method is utilized in this study. This method is capable of concurrently defining the effect of policy parameters on the target policy variable while adjusting for structural similarities amid the nations. Along with this, selecting an appropriate theoretical scheme for scrutinizing this association is essential, as the investigation will be performed for apprehending the evolutionary influence of the policy parameters on the target policy variable. For that reason, the cubic specification of the Environmental Kuznets Curve (EKC) hypothesis proposed by Shafik and Bandyopadhyay (1992) has been selected, as this form of the augmented EKC hypothesis framework can encompass the evolutionary influence over a broad temporal spectrum within a panel data framework. Application of this notional schema has provided the present research with compliance to embody the circumstantial shreds of evidence in a much inclusive way, and consequently, the predicted model outcomes might be able to endorse robust consequences for this context, which can be emulated for other emerging economies across the world. This methodological outline might be thought as the analytical contribution of the study. Furthermore, we provided a long-term strategy to navigate the environmental pollution without hampering economic growth process. The proposed strategy can be considered as a major contribution of the study because it provides a synergy between economic and environmental policies, which may help policymakers to achieve certain sustainable development goals.

The next section briefs about the review of relevant literature. The third section justifies the data and carried the research approach. Thereafter, the fourth section deliberates and discusses the computed results of the study. Lastly, the conclusion and suggestions are placed in the fifth section of the study.

2. Literature examination

2.1 Economic growth and environmental quality

Graphically, the EKC hypothesis exhibits an inverted *U*-shaped association between an environmental indicator and domestic production. Theoretically, it explains that the quality of the environment worsens with the increased production level in the beginning. In this stage, the scale effect maneuvers the economic activities and opens the scope for energy consumption manifold. Owing to the pervasive use of superseded procedures of production and carbon-intense energy resources, the level of environmental pollution increases significantly. However, after achieving a level of production and per capita income, the use of innovative, cleaner and energy-efficient resources and production processes allows maneuver of composite effect. As a result, it contributes to fortifying the environmental quality in a region. Such kind of asymmetric association is usually tested in the literature (Kanzilal and Ghosh, 2013; Rana and Sharma, 2019). However, first of all, Panayotou (1993) in his study named it the EKC hypothesis. Before this, the World Development Report (1993) defined it as the increased economic activities that may be contributed to environmental pollution. In the beginning, the growing level of pollution caused by the enlarged economic activities may be difficult to control with the prevailing techniques of production and environmental measures. However, an unfailing increase in income may allow them to embrace advanced and energy-efficient techniques, and people may start paying more attention to the ecological system. Increased environmental consciousness may help in correcting environmental imbalance (World Bank, 1993). The outcomes of various studies corroborated this notion where the initial impact of the per capita income on environmental pollution is observed to be direct or positive; and after a certain level of income, their association turned into negative or indirect (Haseeb *et al.*, 2018). However, majority of panel data studies in the past have explored the EKC in OCED (Iwata *et al.*, 2012), Europe (Dogan and Inglesi-Lotz, 2020) and European Union countries (Mazur *et al.*, 2015), BRICS (Danish *et al.*, 2019), Asia Pacific Economic Cooperation (APEC) countries (Zaidi *et al.*, 2019), Asia (Taguchi, 2012), South Asian (Sharma *et al.*, 2020) and East Asian countries. Ibrahim and Rizvi (2015) in their study tested the EKC hypotheses by using the panel of South and Southeast Asian countries. However, they ignored the possibility of the *N*-shaped association. Furthermore, the results in their study are computed using the dynamic ordinary least squares, which is unable to address the cross-sectional effect.

Besides, researchers have started investigating the *N*-shaped association between environmental quality and national income. The *N*-shaped association indicates that the investment in fortifying the environmental quality is lagging behind the investment in economic endeavors. This situation commonly appears in those countries where economic growth is the main objective of policymakers. The last stage where once again environmental pollution starts increasing can be circumvented by accommodating cleaner, energy-efficient and advanced techniques of production (Bovenberg and Smulders, 1995). However, the thrust to achieve economic targets motivates governments to continue with the existing techniques of production and ignore environmental issues (Sharma *et al.*, 2020). Therefore, the last stage is the outcome of the lack of synchronization between economic and environmental policies or economic and environmental investments. Stating differently, the negative externalities surpass the technological effect and catalyze the ecological imbalance (Balsalobre and Álvarez, 2016). The validation of the *N*-shaped EKC not only divulges the environmental quality but also existing techniques of production in the region under study.

In this context, Lee *et al.* (2009), Lipford and Yandle (2010) and Sharma *et al.* (2020) using the sample of middle-income and high-income countries, Group-8 (G8) and South Asian countries confirmed the *N*-shaped EKC in their respective studies. In these studies, the coefficients of linear, squared and cubic terms are found positive, negative and positive, respectively. However, this kind of sequencing confirms merely the first-order condition. These studies do not validate the second-order condition, which is a necessary condition for the stable equilibrium. For a stable equilibrium, the calculation of the second-order derivation should provide positive value [1]. In our study, we have tested the validity of the first and second-order conditions. At the same time, we considered the cross-sectional dependency, which is very much possible in the open economies. Studies in the past have ignored the pooling of South and Southeast Asian countries to examine the *N*-shaped EKC hypothesis; therefore, this research gap encouraged us to test the *N*-shaped EKC in the region.

2.2 Financial development and environmental quality

The financial sector is the backbone of an economy, as it ensures the regular flow of savings and investment through the banking sector and other related agencies. Therefore, a diversified and information-technology-based financial sector is required to facilitate the flow of transactions, information and other services (World Bank, 2012). Its development may strengthen the economic environment. However, by channelizing the productive resources, its expansion may widen the scope for energy consumption, which in turn may lead to environmental pollution in the long run (Sadorsky, 2010). However, the association between both may be time and region-specific (Islam *et al.*, 2013). In other words, the impact of financial development on the quality of the environment is not found consistent in past studies. For example, the results of Abbasi and Riaz's (2016) study reveal that the financial sector expansion has contributed to intensifying the pollution level in Pakistan. Similarly, Bekhet *et al.* (2017) in their study confirmed that the upgrading on the financial front has significantly increased the environmental pollution in GCC and South Mediterranean countries, respectively. On the other hand, by taking the case of Indonesia, Shahbaz *et al.* (2013) in their study observed that the growth of the financial sector has fortified environmental quality in Indonesia.

Intuitively, financial sector development and pollution abatement need to be tackled simultaneously. The environmental quality may deteriorate if the latter is neglected to develop the former. Here it is important to mention that these countries have reformed their financial sectors in the preceding three decades (Park, 2011). Therefore, it would be relevant to investigate whether the financial sector development has intensified environmental pollution significantly in the South and Southeast Asian countries.

2.3 Energy consumption, trade expansion and environmental quality

The reckless usage of nonrenewable energy resources cannot be continued due to the two evident reasons; firstly, these resources are less in quantity; secondly, in comparison to renewable energy resources, they are more carbon-intense (Jochem *et al.*, 2015). The growing energy demand in the whole world has aggravated the scope of nonrenewable further. However, policymakers and researchers often recommend widening the scope for renewable energy resources, as renewable energy consumption does less harm to the established ecosystem. Besides, these resources can be replenished provided the required infrastructure is well in place (Gielen *et al.*, 2019). However, despite knowing the harmful effects of nonrenewable energy resources, regions such as South and Southeast Asia are highly dependent on these resources (Sharma *et al.*, 2020). Studies in the past confirmed that the level of pollution in a country or a region got intensified due to the use of nonrenewable energy resources (Katircioğlu and Taşpinar, 2017; Alola *et al.*, 2019). Contrarily, by using the sample of African countries, Yusuf *et al.* (2020) in their study exhibited that energy consumption has not influenced carbon emissions significantly during the study period. Such kind of uncertainty motivated us to examine whether nonrenewable energy consumption leads to CO_2 emissions in the selected countries.

Globalization is embraced as a tool to mitigate technological and financial deficiency by developing countries (Soobramanien and Worrall, 2017). However, in terms of environmental pollution, the role of trade expansion has remained debatable. In this regard, by supporting the Pollution Haven Hypothesis, Bogmans and Withagen (2010) revealed that the weak environmental policies allowed the entry of carbon-intense industries in developing countries, which in turn increased the pollution level in the long run. Stating differently, due to the lack of harmonization between trade policy, economic policy and environmental policy, the level of pollution in open economies got intensified in the long run. In conformity to this notion, Andersson (2018) in his study revealed that the weak environmental policies adopted for the export of the utility sector contributed to raising the pollution level in China. Lack of private investment in the utility sector generated economic and environmental inefficiency, as the government's funds were insufficient for adopting energy-efficient and cleaner production processes. Therefore, it is not wrong to mention that the more impatient countries in the international markets have borne the heavy burden of pollution emissions, as their growing economic requirements and mass population compelled them to adopt the trade-led growth route (Sharma *et al.*, 2019). Similarly, Shahbaz *et al.* (2016) in their study revealed that by compromising the environmental challenges led by the trade expansion, the developing countries have carried their economic growth programs. However, such kind of growth strategy has contributed to global warming and disturbed the ecosystem in both developed and developing nations (Zaidi *et al.*, 2019).

Here it needs to accept that the coordination between environment and trade policies may contribute to refining the established ecosystem in a country. For example, using the case of China, Chang (2012) in his study observed that the increased volume of export, led by cleaner production processes, reduced the solid waste during the study period (1981–2008). Similarly, Faiz-Ur-Rehman *et al.* (2008) in their study mentioned that the environmental quality might be improved by the trade-oriented projects if these are sanctioned after considering their environmental viability. Thus, the positive/negative effect of trade expansion depends on various factors such as the types of goods and services traded in international markets, the economic and environmental policies of the country and above all, the level of environmental consciousness of the various stakeholders (Surugiu and Surugiu, 2015).

Keeping the earlier discussion into consideration, economic growth, financial sector development, energy solutions and trade expansion are recognized as the determinants of CO_2 emissions in the eight developing countries of South and Southeast Asia. To promote SDGs, these variables are certainly crucial, as the economic growth pattern of these countries is dependent on internal and external factors.

3. Research approach

Literature supports that the economic endeavors may have negative influence on the quality of environment (Rajpurohit and Sharma, 2020; Shahbaz *et al.*, 2021). However, the association between economic growth proxy and environment quality may not be smooth or similar across counties and periods. Besides, certain economic transitions such as financial sector development (Shahbaz *et al.*, 2020) and trade expansion (Sun *et al.*, 2019) may help in restoring the environmental quality in the long run. Therefore, it is a matter of discussion whether the developing nations such as South and Southeast Asia have framed their economic policies in line with the SDGs. If it not so, we need to suggest a long-term strategy so that environmental targets can be achieved without disturbing economic growth.

In this pursuit, by considering the growth strategy of these nations, it is essential to scrutinize the influence of these policy parameters on carbon emissions based on an appropriate theoretical framework, which should permit the evolutionary impact of these parameters over a temporal setting. In consequence of this purpose, the present research has undertaken the EKC hypothesis, which can capture this evolutionary impact into its framework. The revised definition of the EKC hypothesis, as explicated by Shafik and Bandyopadhyay (1992), delineates this impact, following an augmented cubic form of the generally accepted form of EKC. In terms of mathematical depiction, this framework can be elucidated as per the following:

$$\mathrm{CE}_{it} = a_0 + a_1\mathrm{EG}_{it} + a_2\mathrm{EG}_{it}^2 + a_3\mathrm{EG}_{it}^3 + a_4 Z_{it} + \epsilon_{it} \tag{1}$$

Here, CE symbolizes the carbon emissions, EG is a measure of economic growth and Z is the matrix of additional covariates to have a possible impact on CE. "i" and "t" symbolize the nations and years. Following the context of the nations under consideration, Z can be represented as:

$$Z = (\mathrm{TV}, \mathrm{FM}, \mathrm{NR}) \tag{2}$$

Here, TV symbolizes trade volume, FM symbolizes financial mobilization and NR symbolizes the extraction of natural resources. Owing to the corresponding evolutionary impacts of Z being anticipated to be positive, they are exogenous to the EKC framework. Conversely, the evolutionary impact of EG is unknown, and by dint of the investigation, the present research focuses on discerning that. In accordance with the cubic specification of EKC hypothesis, the necessary condition for the *N*-shaped form of association is: $a_1 > 0$, $a_2 < 0$, and $a_3 > 0$, while the sufficient condition is $a_2^2 - 3\,a_1 a_3 > 0$ (for detailed derivation of conditions, see Sinha *et al.*, 2019). This associative schema might proffer a conceivable suggestion regarding the evolutionary impact of economic growth on carbon emissions.

Growing economic performance causes an upswing in environmental degradation. Once arriving at a threshold, the pattern of economic performance leads to the fading of environmental degradation. Nevertheless, this catalytic influence does not generate spontaneously. Growing economic performance leads to augmentation in the extraction of natural resources, which are subsequently utilized in the production processes, and resultant environmental deprivation commences. While nations begin capitalizing on innovations, steady enhancement in production efficiency ushers in. Improvement in energy efficiency might reduce demand for natural resources, and henceforward, diminishing of the negative environmental externality exerted by the process of natural resource consumption commences. In this course, international trade relations might permit technological transactions between countries, and consequently, progressively these nations can construct their competence to innovate, grounded on the improvement in living standard and scholastic fulfillment. So, until the endogenous capability development of the nation reaches a certain threshold, trade volume exerts negative environmental externality by speeding up production procedures. Shahbaz *et al.* (2019) have discussed this issue in detail.

For estimation purpose, Equation (1) can be represented as:

$$\begin{aligned} \ln CO_{2it} &= a_0 + a_1 \ln IPC_{it} + a_2 (\ln IPC_{it})^2 + a_3 (\ln IPC_{it})^3 + a_4 \ln TE_{it} + a_5 \ln IFD_{it} \\ &\quad + a_6 \ln NRE_{it} + \epsilon_{it} \end{aligned} \tag{3}$$

Here, CO_2 symbolizes the per capita carbon emissions, IPC is a measure of per capita GDP, NRE is the indicator of per capita nonrenewable energy consumption, TE is the measure of trade expansion calculated as a ratio of the sum of export plus import to GDP and IFD is the financial development index. Data for all the variables have been collected from World Bank indicators (2019). For this study, a separate financial development index (IFD) has been prepared, and it has been duly discussed in the following section.

3.1 Financial development index

Using the principal component method, we calculated the financial development index. The selection of an appropriate proxy for financial sector development is essential. Ang (2008) ascertained that the impact of a particular proxy for financial development might vary significantly across countries. In this regard, the literature provides a list of variables that are used interchangeably to depict the progress of the financial sector of a country. This ambiguity motivated us to construct a financial sector development index. Based on the literature (Katircioğlu and Taşpinar, 2017), we included: (1) broad money supply (% of gross domestic production) (BM); (2) lending by the private sector (% of gross domestic production) (LBP); (3) domestic lending to the private sector (% of gross domestic production) (DLP); and (4) liquid liabilities on government (annual growth as % of broad money) (LL). All the indicators mentioned in Equations (3) and (4) are retrieved from the World Bank's database. Based on Equation (4), we derived the financial development index.

$$IFD = f(BM, LBP, DLP, LL) \tag{4}$$

For the development of the financial sector, broad money supply, liquid liabilities (Beck *et al.*, 1999), domestic lending to the private sector (Jenkins and Katircioglu, 2010) and credit by the private sector (Levin *et al.*, 2000) are considered vital instruments in the past studies.

Besides, the growth in stock markets can be considered as a driver of the financial sector (Beck *et al.*, 1999). Due to the persistent fluctuations in the stock markets, this variable is not included in the financial development index; hence, it can be considered as a limitation of the study.

The variables carried in Equation (4) are used to compute the principal component analysis. By giving the due weight to the considered variables, the associated variables will be transformed into a lesser number of uncorrelated variables. Besides the principal component analysis, we considered the varimax rotation, which enabled us to retrieve the composite index for financial development. For calculating the index, we considered the Eigen and cumulative values, which permitted us to select the important variable/s. By considering the statistically preferred criteria, the eigenvalue of one variable is found to be more than 1 (Beck *et al.*, 1999).

The mechanism to construct the composite index is given in Equation (5)

$$\mathrm{IFD} = \sum_{i=1}^{n} Li \times \mathrm{FS} \tag{5}$$

Here, IFD denotes the financial development, Li is weight/load of each proxy divided by the total variation explained by the all proxies and FS denotes respective factor scores of each considered variable. The mechanism to calculate the Li is given in Equation (6):

$$Li = \left(\frac{\mathrm{EV}i}{\sum_{i=1}^{n} \mathrm{EV}i} \right) 100 \tag{6}$$

Here, $\mathrm{EV}i$ = explained variance share of each factor (i), and n = number of factors.

Results given in Table 1 enabled us to compute the composite index for financial development in the eight developing countries of South and Southeast Asia. Except for the first component (3.810 > 1), the eigenvalues of all the components are less than 1. Furthermore, the first component explains the 95.2% variation; therefore, using the one component, we extracted the index. However, in the final index, the factor scores of other variables are used to represent their weights. In the study of Katircioğlu and Taşpinar (2017) also only one component's eigenvalue was found to be above than 1; and factor scores of other variables are weighted to compute the final index.

3.2 Panel cross-sectional dependency

Before apprehending the results of the regression analysis, we need to confirm whether series possess the desired properties of the stationarity. The present study is based on the panel data

	Financial sector development		
Principal component	Eigenvalues	Variance (%)	Cumulative variance (%)
1	3.810	0.952	0.952
2	0.118	0.029	0.982
3	0.054	0.013	0.995
4	0.016	0.004	1.000
Indicators	Factor loading	KMO score	Factor scores
BM	0.499	0.877	0.148
LBP	0.501	0.836	0.221
DLP	0.504	0.752	0.425
LL	0.500	0.777	0.207
Overall	–	0.807	–

Note(s): The principal component is based on one factor. Using the factor scores, the financial development index is calculated

Table 1. Results of principal component mechanism

framework; therefore, the likelihood of the cross-sectional dependency cannot be denied. The possible spillover impacts of the macroeconomic variables such as trade agreements, labor, energy and technology are well recognized. In this case, the traditional tests may not be sufficient to detect the stationarity issue. To address this matter, Pesaran's (2004) cross-section dependence (i.e. Pesaran CD) test can be applied provided the panel set is large, and the study period is small, whereas the Pesaran Lagrange multiplier (Pesaran LM) test is more suitable when the period of study is large (PS) and country-sample (CS or number of countries) is small. In our study, the cross-sectional dependency can be a crucial factor; therefore, we have used Breusch and Pagan (1980), Pesaran CD and Pesaran LM test to diagnose whether series possess cross-sectional dependency over the period in the selected countries. Equation (7) explains the mechanism for calculating the CD stationarity test. Here, the null hypothesis proposes the presence of cross-sectional independence where PS→∞ with a sufficiently large CS.

$$\mathrm{CD} = \frac{\sqrt{2\mathrm{PS}}}{\mathrm{CS}(\mathrm{CS}-1)}\left(\sum_{i=1}^{\mathrm{CS}-1}\sum_{q=l+1}^{\mathrm{CS}} \mathrm{pc}_{iq}\right) \tag{7}$$

In Equation (7), CD is cross-sectional convergence, and PS, CS and pc_{iq} are carried to denote the study period, countries and correlation (pair-wise), respectively.

3.3 Cross-sectional unit root tests

Further, to corroborate the stationarity with the cross-sectional dependency, we run the cross-sectional augmented Dickey–Fuller (CADF) procedure. The computational mechanism is mentioned as follows in Equation (8):

$$\Delta x_{i,t} = \beta_i + \rho_i x_{i,t-1} + \theta_{it} + \sum_{l=0}^{r} \lambda_{i,l}\Delta x_{i,t-j} + \underline{\epsilon}_{i,t} \tag{8}$$

Here ρ_i, Δ, x, $\underline{\epsilon}$ symbols are used to express the persistence parameters, difference operators, variable to be explained and white noise error term, respectively. Further, the trend components and lag length are denoted by λ and r, respectively. By assuming homogeneity, if $\rho_{\mathrm{I}} = \rho$ and $\rho = 0$, we can say that the series is not stable. Contrarily, $\rho < 0$ confirms the series stability. The t-statistics are calculated by the separate treatment of the ADF statistics. Thereafter, by using the mean values of the CADF results, the cross-sectional augmented Im–Pesaran–Shin test results are obtained (CIPS) where the cross section is treated individually.

$$\mathrm{CIPS} = \left(\frac{1}{\mathrm{CS}}\right)\sum_{i=1}^{\mathrm{cs}} t_i(\mathrm{CS},\ \mathrm{PS}) \tag{9}$$

Here, CS and PS are used to denote countries and period of study, respectively.

3.4 Cointegration approach

Further, to investigate the long-run cointegration, we employed Westerlund's (2007) approach. By generating the error correction term, this approach provides possible cointegration in the presence of cross-sectional dependency. Based on the calculated values (i.e. G_t, G_a, P_t and P_a), we can ascertain whether the included variables are cointegrated in the long run. The mechanism to calculate the results of Westerlund test is given as follows:

$$\Delta X_{i,t} = \lambda_i c_t + \beta_i X_{i,t-1} + \rho_i Z_{i,t-1} + \sum_{l=1}^{p_i} \beta_{i,l}\Delta X_{i,t-l} + \sum_{l=-q_i}^{p_i} \gamma_{i,l} Z_{i,t-1} + \mu_{i,t} \tag{10}$$

In Equation (10), the constant term (i.e. (1) – constant trend, (0) – no constant trend and (1, t)' – constant and trend) and speed of adjustment are denoted by c_i, and β_i, respectively. By navigating the cross-sectional dependency, Pesaran (2006) provided the unique solution of the stationarity. The error term carried in Equation (1) can be calculated as:

$$\epsilon_{it} = \lambda_i \mathrm{UM}_t + \mu_{i,t} \tag{11}$$

Here UM_t = unnoticed factors matrix (m x 1). To get the consistent proxies for the UMt, here average of the cross section is used, which efficiently manages the issue of cross-sectional dependency. For example: $\ln\overline{\mathrm{CO}_{2t}} = 1/N\sum_{i=1}^{\mathrm{N}} \ln\mathrm{CO}_2$. Similarly, we can calculate the values of other variables. By doing so, we will get the regression equation as follows:

$$\begin{aligned}\ln\mathrm{CO}_{2it} = {} & a_0 + a_1\ln\mathrm{IPC}_{it} + a_2(\ln\mathrm{IPC}_{it})^2 + a_3(\ln\mathrm{IPC}_{it})^3 + a_4\ln\mathrm{TE}_{it} + a_5\ln\mathrm{IFD}_{it} + a_6\ln\mathrm{NRE}_{it} \\ & + \Phi_0\overline{\ln\mathrm{CO}_{2t}} + \Phi_1\overline{\ln\mathrm{IPC}_{it}} + \Phi_2\overline{(\ln\mathrm{IPC}_{it})^2} + \Phi_3\overline{(\ln\mathrm{IPC}_{it})^3} + \Phi_4\overline{\ln\mathrm{TE}_{it}} + \Phi_5\overline{\ln\mathrm{IFD}_{it}} \\ & + \Phi_6\overline{\ln\mathrm{NRE}_{it}} + \epsilon_{it}\end{aligned} \tag{12}$$

In Equation (12), the *Common Related Effect* is based on the values of individual coefficients (i.e. Φ_1 to Φ_6).

3.5 The CS-DL approach

Recently, to address the problem of cross-sectional dependency, the two new approaches, that is, cross-sectional autoregressive distributed lag and cross-sectional augmented distributed lag approaches have come forth (Chudik *et al.*, 2015). The CS-ARDL approach provides the coefficients of both periods and handles the cross-sectional dependency. However, CS-DL approach is to be considered superior to CS-ARDL approach due to the following reasons: (1) when the time dimension is moderate and the sample size is small, the CS-DL approach handles the cross-sectional dependency efficiently (Anderson and Raissi, 2018); (2) by using the truncation in the lag order, the CS-DL approach reduces the requirement of the long lags; (3) a major advantage of the CS-DL approach is that it addresses the serial correlation and structural discontinuity more efficiently than CS-ARDL (Anderson and Raissi, 2018).

4. Results and discussion

First of all, to represent the financial development in the system, we carried the principal component approach. The results for the same are mentioned in Table 1. After constructing, the financial development index, the basic properties of the comprised data series need to be apprehended. Table 2 exhibits the attributes of the income, financial development, trade expansion and nonrenewable time series.

The linear, squared and cubic per capita series have shown maximum deviation followed by carbon emissions series. Except for the carbon emissions series, the probability values of the Jarque–Bera test are significant. Thus, it can be interpreted from the results of Table 2 that the series are abnormally distributed and spread is uneven during the study period. Similarly, except for the carbon emissions, all other series have shown positive skewedness. Subsequent to this, we can carry out empirical analysis.

In order to ascertain the applicability of the second-generation methodological approach, it is necessary to assess the cross-sectional dependence prevailing in the data, and the Pesaran CD, Pesaran scaled LM and Breusch–Pagan LM tests are conducted in this pursuit. The test outcomes reported in Table 3 designate the presence of cross-sectional dependence in the data.

Table 2. Descriptive statistics of the variables (after log transformation)

	$lnCO_2$	lnIPC	lnIFD	lnTE	lnNRE
Mean	0.197	6.964	0.101	3.927	3.902
Median	0.174	6.858	−0.488	3.756	4.082
Maximum	2.108	9.322	2.835	5.258	4.574
Minimum	3.394	5.1475	−1.070	2.574	1.619
Std. dev.	1.217	1.019	1.002	0.648	0.670
Skewness	−0.004	0.380	1.211	0.306	−1.737
Kurtosis	2.517	2.295	3.118	2.254	5.1575
Jarque–Bera	2.008	9.262	50.775	8.028	144.326
Probability	0.366	0.009***	0.000***	0.018**	0.000***
Observations	208	208	208	208	208

Note(s): *** ≤1%, and **≤ 5% significant level (rejection of the null hypothesis of normal distribution)

Table 3. Cross-sectional dependence test

Indicators	Pesaran CD	Pesaran scaled LM	Breusch–Pagan LM
$lnCO_2$	22.862***	66.236***	531.666***
lnIPC	26.006***	85.606***	676.624***
$lnIPC^2$	26.056***	85.948***	679.181***
$lnIPC^3$	26.095***	86.223***	681.237***
lnIFD	6.424***	22.168***	201.894***
lnTE	4.913***	18.307***	172.997***
lnNRE	23.853***	71.529***	571.274***

Note(s): *** = The rejection of absence of cross-sectional dependence at 1% significance level

Once the cross-sectional dependence among the model parameters is ascertained, the order of integration among the model parameters can be assessed, so that the presence of cointegrating association among them might be sanctioned. The outcomes of CIPS and CADF tests recorded in Table 4 confirm that the model parameters are first-order integrated. This evidence sanctions the application of cointegration test.

Following the evidence of the order of integration among the model parameters, it is necessary to assess the presence of cointegrating association among model parameters, so that subsequently the long-run coefficients can be assessed. In this pursuit, Westerlund's (2007) cointegration test is conducted, and the test outcome recorded in Table 5 assures the presence of cointegration among the model parameters, in the presence of cross-sectional dependence.

Table 4. Results of second-generation unit root tests

	CIPS		CADF	
Variables	Level	First difference	Level	First difference
$lnCO_2$	−0.363	−4.798***	−1.186	−2.757***
lnIPC	−1.345	−4.672***	−1.616	−3.349***
$lnIPC^2$	−1.265	−4.517***	−1.637	−2.930***
$lnIPC^3$	−1.207	−4.310***	−1.679	−3.004***
lnIFD	−0.998	−3.609***	−1.017	−4.117***
lnTE	−0.659	−4.224***	−1.142	−3.084***
lnNRE	0.100	−4.589***	−1.756	−3.473***

Note(s): *** = The rejection of absence of cross-sectional dependence at 1% significance level

Lastly, we will move toward the estimation of long-run coefficients by the CS-DL approach. The test outcomes are reported in Table 6. We will start analyzing the evolutionary impact of IPC on carbon emissions. Across three empirical models, The IPC-CO_2 emissions association is representing an *N*-shaped EKC, which has been suggested by Shafik and Bandyopdhyay (1992). By design, this association proffers two turnaround points, and these points divulge the nature of negative environmental externality exerted by the economic growth pattern in these nations. For all the three models, the first turnaround points are below the average, which might signify that the economic growth pattern is allowing the decrease in carbon emissions at a very early stage of growth. However, the presence of the second turnaround point within the sample range demystifies the earlier finding, and it shows that the growth pattern is actually allowing the carbon emissions to rise. Therefore, the evolutionary impact of economic growth in these nations is responsible for the elevation in the carbon emissions in these regions, and therefore, the growth trajectory might be responsible for these nations to drift away from attaining the objectives of SDG 13. The quest for economic growth in these nations might be causing policy-level myopia, driven by which environmental protection is gradually turning out to be a secondary agenda for the policymakers. Sinha *et al.* (2017) found a similar kind of association in a study on the Next-11 economies. Owing to the structural similarities, finding of the present study can be considered as an extension of the findings of Sinha *et al.* (2017).

As economic growth cannot sustain without the financial mobilization, therefore, financial mobilization can be considered as a driver of growth in these nations, and going by the scope of this driver, it might have negative environmental consequences. The coefficients of IFD across Model II and III support this argument. The financial mobilization has allowed availability of credit to the industrial players, so that they can directly contribute to economic growth. For achieving economic growth, policymakers focused more on the economic achievements by the industrial sector, rather than protecting the environmental quality, and this intention of the policymakers has been supported by the financial mobilization pattern in these countries. Therefore, the economic growth pattern achieved by these nations has been

Tests	Value	*p*-value	*p*-value (bootstrap)
Gt	−6.076***	0.000	0.000
Ga	−3.999	0.998	0.110
Pt	−6.382*	0.370	0.090
Pa	−9.431**	0.570	0.049

Note(s): *** ≤ 1%, **≤ 5% and *≤ 10% are showing significance at 1, 5 and 10% levels, respectively

Table 5. Results of Westerlund's cointegration tests

Variable	Model I	Model II	Model III
lnIPC	16.108***	18.681***	18.785***
$lnIPC^2$	−2.090**	−2.850***	−2.347**
$lnIPC^3$	0.090**	0.137**	0.097**
lnIFD	–	0.143***	0.245***
lnTE	–	0.176**	0.128*
lnNRE	–	–	0.575**
Shape of EKC	*N*-shaped	*N*-shaped	*N*-shaped
Turnaround point 1	$ 1381.64	$ 202.74	$ 1573.81
Turnaround point 2	$ 3829.37	$ 5201.32	$ 6433.87

Note(s): *** ≤1%, **≤ 5% and *≤ 10% are showing significance at 1, 5 and 10% levels, respectively

Table 6. Results of the mean group estimation using the CS-DL approach

found to exert negative environmental externality. Shahbaz *et al.* (2015) and Haseeb *et al.* (2018) have found a phenomenon of similar stature. This negative impact has been further catalyzed by trade expansion, as the demand for technological development and other factors of production for industrial growth have been fulfilled by international trade. From this perspective, the trade expansion, in the capacity of a growth driver, has exerted negative environmental externality using industrial growth. The coefficients of TE across Model II and III support this argument. Trade expansion has allowed the industrial players to have control over technological developments for augmenting their production processes, and in this pursuit, the trade expansion has allowed the environmental quality to deteriorate through the industrial expansion. This segment of the outcomes refutes the finding of Shahbaz *et al.* (2017), where it has been argued that the developing countries have not achieved the potential benefits of globalization, as the socioeconomic conditions prevailing in emerging economies prevent to generate spillovers. Therefore, the direct impact of trade expansion on environmental quality might have remained insignificant in these countries.

Lastly, it also needs to be remembered that industrial progression cannot occur without the consumption of energy solutions, which is predominantly nonrenewable in nature. Combustion of nonrenewable energy solutions generates CO_2 emissions through the oxidization of the hydrocarbon structure of the fuel, and thereby, nonrenewable energy solutions exert negative environmental externality. The coefficient of NRE in Model III supports this argument. The rise in industrialization creates demand for more energy, and in this process, extraction and combustion of nonrenewable fossil fuels take place. Moreover, because of concentration in vocational opportunities, the rise in the urban population generates demand for energy, which consequently results in the consumption of nonrenewable energy solutions. Recent evidence by Sharif *et al.* (2020) supports this segment of the findings. This phenomenon caused by the elevation in economic growth trajectory gradually defeats the basis of attaining the objectives of SDG 7 and SDG 11.

5. Conclusions and policy for sustainable growth

The challenges faced by the eight South and Southeast Asia countries in attaining the SDG objectives motivated us to examine the impact of economic growth, financial mobilization, international trade and nonrenewable energy consumption on the carbon emissions for the period of 1990–2015. In doing so, the second-generation methodological approach has been adopted, while the theoretical underpinning was founded on the cubic specification of the EKC hypothesis. Results confirm the evolutionary impact of economic growth on carbon emissions to be following *N*-shaped EKC, whereas financial mobilization, international trade and nonrenewable energy consumption found to have contributed toward the rise in carbon emissions.

The outcomes of the study confirmed an *N*-shaped association between carbon emissions and per capita income in the selected nations. Therefore, we can ascertain that the positive impact of economic growth turned into negative at the higher level of income because the excessive production once again might have enlarged the consumption of carbon-intense energy solutions. As a result, growing economic activities can be considered as a catalyst for environmental pollution in the long run. Further, we observed that the increased consumption of nonrenewable energy solutions, growing international trades (i.e. exports and imports) and financial sector development have invigorated the carbon emissions during the study period. It means, the cumulative influence of the selected economic endeavors challenged the established ecosystem and South and Southeast Asian nations are keeping the environmental issues at the backseat.

Based on the obtained results, it might be contemplated that the growth trajectory attained by these nations is catalyzing them to take a departure from accomplishing the objectives of SDG 13, SDG 7, SDG 11 and SDG 8. Therefore, a policy framework needs to be designed, so that these nations can make progressions in achieving these SDG objectives. Now, in view of the prevailing growth trajectory in these nations, it is well understood that the replacement of fossil fuel energy solutions with renewable energy solutions might help these nations to achieve a sustainable growth path. However, an overnight replacement of energy sources might hamper the growth trajectory itself, as the cost of renewable energy implementation is very high. On the other hand, this replacement might come at a cost of employment in the mining and thermal power generation sectors. Therefore, the policy moves need to internalize these issues, while accounting for the environmental issues caused by the growth pattern. In this pursuit, the policies need to be implemented in a phased manner. In the first phase, the policymakers should import renewable energy solutions from the developed nations and make them available for the domestic industries against a pro-rata lending rate. The lending rate to be decided by the financial institutions needs to be based on the carbon footprint of the firms so that the dirtier industries will have a less preference by the government over the comparatively cleaner industries. However, in order to accommodate the implementation cost of renewable energy solutions, the firms might be provided with a certain interest rate holiday, based on the revenue stream of the firms. This will help them to make a progression toward attaining the objectives of SDG 13 and SDG 7. Once the firms start making progress in adopting these technologies, then the nations might move toward the second stage of implementation. As it can be evident that during the first phase, the nations will undergo a trade deficit, as renewable energy solutions will be imported to the nation. Therefore, in this phase, the policy moves will be directed toward improving the trade balance through exporting the products. As during the first phase, the firms have been able to successfully make a progression toward renewable energy implementation, the production will be cost-effective. At this stage, the government might provide subsidies to the firms, based on their readiness to enter the international market with the products made out of renewable energy solutions. This will help the firms not only to compete in the international market but also to create vocational opportunities. Hence, the nations will be starting to move toward attaining the objectives of SDG 8. Once these two phases are accomplished, then the policy move should be directed toward stabilizing these two stages and making a progression toward attaining other SDG objectives. In this pursuit, the policymakers should discourage the usage of fossil-fuel-based solutions by imposing a higher tax rate, and the financial institutions should be imposing a higher lending rate for the projects, which utilize the fossil-fuel-based solutions. This will gradually discourage the firms to utilize the fossil-fuel-based solutions for energy consumption, and this might lead to a reduction in the extraction of nonrenewable resources. This will help the nations to take a step toward attaining the objectives of SDG 11.

While actuating this policy framework, the policymakers need to maintain certain caveats, without which this framework might not prove to be successful. First, during the phased implementation of the policy framework, the policymakers should be careful about the nature of technologies being imported, as the import of dirty or outdated technologies might defeat the very purpose of the policy implementation. Second, while carrying out this policy framework, there will be evident unemployment in the mining sector. The policymakers, as notwithstanding this condition might harm the socioeconomic scenario of the nation, should consider reallocation of these laborers into new vocational engagements. Third, in order to make these policies reach the grassroots level, the policymakers need to ponder upon transforming the educational curriculum for emphasizing on spreading environmental awareness. This move will make future citizens more environmentally aware, and in that way, it will be much easier for policymakers to protect environmental quality.

The policy framework suggested in this study suffers from certain limitations, and a major limitation is the unavailability of data. Any research on this particular geographical context suffers from this limitation, and for the policymakers, this should be a major concern.

As a future direction of research, we want to conduct this study on Asia Pacific countries, following a spatial dependence approach, so that the interdependence of the nations might be captured in a much detailed manner.

Note

1. The details on the necessary and sufficient conditions are given in the research methodology section.

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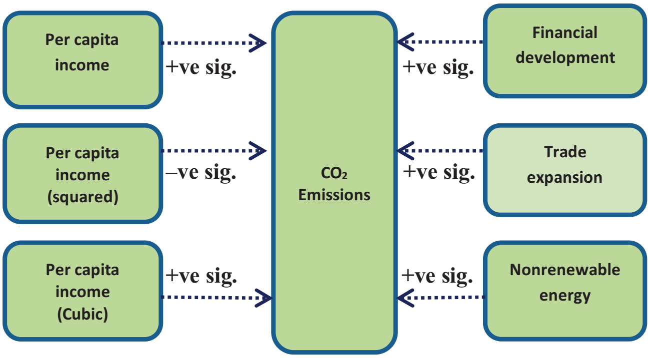
Appendix



Note(s): +ve sig. and –ve sig. are used to denote the positive significant and negative significant impacts, respectively

Figure A1. Examining the impacts of selected variables in the eight developing economies of South and Southeast Asia. (+ve sig. and –ve sig. are used to denote the positive significant and negative significant impacts, respectively)

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