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Revisiting the impacts of globalization, renewable energy consumption, and economic growth on environmental quality in South Asia

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Abstract

Purpose: This study empirically analyzes the impact of globalization, renewable energy consumption, and economic growth on environmental quality in five South Asian developing economies. For this purpose, we used a panel data from 1990 to 2014 for the mentioned countries and employed latest econometric techniques for the empirical analysis.

Study design/methodology/approach: We perform a cross-sectional dependency (CD) test and employ a second-generation panel unit root (CIPS and CADF) tests. Further, in this study, we conduct different panel cointegration tests. Finally, we estimate the long-run association between dependent and independent variables by using both Fully Modified-OLS (FMOLS) and Dynamic-OLS (DOLS).

Findings: The study's empirical results confirm that both globalization and economic growth increase CO2 emissions in South Asian developing economies. On the other hand, renewable energy consumption significantly improves environmental quality. Moreover, this study also confirms that these countries have an inverted U-shaped environmental Kuznets curve (EKC).

Originality/value: The outcomes of this study provide the important policy implications for the governments of South Asian countries for sustainable development in the region.

Keywords: Globalization, Renewable energy consumption, Economic growth, Environmental quality, Sustainable development, South Asia

JEL codes: Q01, Q42, Q56, F6

1. Introduction

In recent literature, the debate on environmental quality is getting huge space. Numerous researchers have identified the different determinants of ecological degradation, including rapid industrialization, population growth, urbanization, deforestation, and increased transportation. In addition, economic growth, energy consumption, globalization, trade, and FDI are also considered influencing factors of environmental quality in literature (Opuala et al., 2022; Rahman et al., 2021; Obiakor et al., 2022). The environmental quality has been worsening recently due to misuse of natural resources, ozone layer depletion, and deforestation (Shahbaz et al., 2017). Therefore, the World is facing various consequences of environmental degradation and global warmings such as increased natural disasters and food shortages caused by low crop yield, and water pollution causing lower seafood production.

There are two major conclusions on the relationship between globalization and environmental quality; first, the GLN has an adverse influence on ecology (Borghesi and Vercelli, 2003) and the second is the positive impact of globalization on environmental quality; however, it depends on environmental policy design and effectiveness (Stern, 2004). Due to globalization (GLN) and trade openness, the demand for energy consumption has significantly increased, which has worsened the environmental quality through emissions of hazardous gases and other materials. GLN has increased the demand for both products and services globally which has stimulated the production level in countries. Therefore, more production requires more energy usage which in turn increases industrial wastes and GHS (Sabir and Gorus, 2019). In the case of developing countries, globalization is witnessed as an adverse effect on the environment because of weak enforcement of environmental regulations (Copeland and Taylor, 2004).

Literature has identified that EC is necessary for the production process however consumption of non-REC reduces EQ (Hasnisah et al., 2019). Energy consumption releases environmentally hazardous gases such as CO2, SO2, NO2, etc. These gases are harmful to ecology (Shahbaz et al., 2019). In another study conducted on West Africa, it has been revealed that energy consumption, trade openness, and urbanization increase environmental degradation (Opuala et al., 2022). However, to minimize the environmental impact, alternative energy such as solar energy, wind, and biomass could be used in transport, household, and industrial usage. Different investigations have concluded a positive relation between REC and EQ (Rahman and Vu, 2020; Bilgili et al., 2015; Hasnisah et al., 2019; Usman et al., 2020). Rahman et al. (2021) examined the relationship between energy consumption, economic growth, and globalization on environmental quality in BRICS countries. The findings state that energy consumption has adverse effects on environmental quality; however, globalization has a negative impact on CO2 emissions. However, the consumption of renewable energy can improve environmental quality as many studies have found a positive and significant impact on renewable energy consumption and environmental quality (Zafar et al., 2019a, 2021; Demirtas et al., 2022).

The relationship between economic growth and environmental quality is also widely discussed in the literature. However, the findings are mix that either economic growth spoils the environment or is better off. The Environmental Kuznets Curve (EKC) is defined as at the initial stage an increase in economic growth reduces ecological quality; however, the increase in GDP improves the environment, which means there is an inverted U-shaped association between GDP and the natural environment. In the initial stage, countries try to increase economic growth by manufacturing and consuming products and services. This process requires the utilization of more resources which decreases environmental quality. After achieving economic goals, countries focus more on the structural shift from conventional ways of production and consumption to eco-friendly manufacturing and utilization. Like other developing economies, the south Asian developing economies, including Bangladesh, India, Nepal, Pakistan, and Sri Lanka, face severe environmental issues. These countries are shifting their economic base from agriculture to the industrial sector, causing environmental degradation (Srinivasan, 2013). Due to the increased population in these countries, the industries, transport, and urbanization have significantly increased which has increased the concentration of hazardous gases in the air and ultimately reduced the environmental quality in this region. Moreover, GHS has been increasing in these countries, causing air pollution in the region (Khwaja et al., 2012; Fan et al., 2020). South Asian countries mainly depend on using non-renewable energies for transport, industries, and houses. In addition, to air pollution, land and water pollution has significantly increased in recent years in this region. Keeping these factors in view, there is an urgent need for time to investigate the various factors of environmental degradation in South Asian countries.

This research contributes to literature to close the knowledge gap. First, this investigation theoretically and empirically analyzes the role of GLN, REC, and EG in EQ in South Asia, which has been rarely discussed in academic literature. Second, this study verifies the existence of the EKC framework through empirical evidence in these countries. Third, this study investigates the subject matter using the latest econometric techniques, such as the cross-section dependency (CD) test. It is used to check the cross-sectional dependence in these countries.

Moreover, we use second-generation unit root tests if CD is present in our data. We conduct different latest panel cointegration tests, including the test developed by Pedroni (1999) and Westerlund (2005). Finally, we employed the latest techniques, FMOLS, and DOLS, to check the long-run association amongst variables. The subsequent parts of the study are as follows: the second part is the literature review, and the third is about materials and methods. While the fourth section presents the results and discussion and the fifth chapter provides the conclusion and policy measures.

2. Literature review

In the available literature, numerous investigations have examined the relationship of GLN, REC, and EG with EQ at a country, regional or global level. However, the findings of relevant studies vary and are inconclusive. Therefore, this study investigates a similar relationship in the case of South Asian developing economies. We develop the hypotheses of this study on the following literature background.

2.1 Globalization and environmental quality

Globalization (GLN) is the degree of openness of a country economically, politically, and socially (Dreher, 2006). In particular, globalization is described as the countries' economic and financial integration, capital market openness, technology and information transformation, and the degree of trade openness in goods and services (Sabir and Gorus, 2019). The concept of GLN has been developed to increase economic integration among countries. GLN has turned the world into a global village. In addition, globalization has increased global trade volume, human capital mobility, and FDI. Besides the economic benefits of GLN, there are specific negative impacts, such as it hurts the natural environment. Different studies are available in the literature on globalization and ecological quality link; however, the findings have mixed results. GLN, in general, boosts economic activities through international trade, FDI, financial integration, and human capital mobility (Saud et al., 2019). GLN increases energy demand in countries, affecting the natural environment (Charfeddine, 2017). Moreover, GLN reduces EQ through non-RE usage. Non-RE utilization increases CO2 and other hazardous gas emissions, reducing air quality (Ahmed et al., 2016). Globalization has fostered industrialization, which has caused to increase the industrial waste and polluted the natural environment in the shape of air, water, and land pollution. Due to weak enforcement of environmental regulations, globalization in developing economies has increased the growth of environmentally polluting industries (Copeland and Taylor 2004).

Moreover, globalization allows trade openness, increasing the imports and exports of products and services and ultimately negatively impacting ecology (Dean, 2002). In addition, the study of McAusland (2008) also provides evidence that trade reduces environmental quality. However, Xu et al. (2018) found an insignificant link between globalization and environmental quality in Saudi Arabian economy. Sharif et al. (2020) analyzed the role of tourism and globalization in environmental quality in the case of China. The results of their study reveal that economic growth has a positive effect on CO2 emissions; however, globalization has a negative impact on environmental quality in China.

In contrast, some other studies found that globalization reduces environmental pollution, such as studies by Shahbaz et al. (2017a, 2017b) and Usman et al. (2020b). They argued that because of globalization, countries must follow international environmental regulations. Henceforth, the

environmental quality will not worsen due to globalization. In line with the above studies, Zafar et al. (2019b) concluded that financial progress and GLN improve ecological eminence by dropping environmentally hazardous substances. Moreover, trade openness and globalization also have different impacts on the environment and depend on the country's environmental policies and enforcement (Copeland and Taylor 2004). Trade could positively impact environmental quality if the country uses clean and environmentally friendly technologies in production (Liddle 2015). This way, a country can benefit economically and environmentally from globalization. Based on previous findings, we developed the following hypothesis for this study.

H1: GLN reduces ecological quality in South Asian economies

2.2 Renewable energy consumption and environmental quality

Using alternative energies in production and process reduces the environmental impact. Various studies have explored the link between REC and EQ. According to Dogan and Seker (2016), REC improves environmental and economic output. RE reduces environmentally hazardous materials and improves ecological quality. Zafar et al. (2019a) examined the association between REC and CO2 emission in different countries. Their findings show that consumption of RE in G-7 and N-11 countries improves the environmental quality by significantly reducing CO2 emissions. Another researcher Zoundi (2017), also investigated the same relationship on panel data of 25 African economies. This research reveals that RE consumption significantly improves environmental quality, whereas the EKC does not exist in these countries. According to Usman et al. (2020a), RE consumption improves ecological quality in the USA, and GDP growth increases environmental degradation. In line with their study, Ike et al. (2020a) concluded that RE consumption in G-7 countries significantly reduces environmental damage, and EKC exists in these economies. Moreover, Liu et al. (2017) also analyzed the effects of REC on ecological quality. Their results support the statement of Dogan and Seker (2016), Jiang et al. (2021), Zafar et al. (2019a), and Zoundi (2017) that REC is significantly better for the natural environment by reducing hazardous gases. Other studies also found that renewable energy consumption improves environmental quality such as the study of Zafar et al. (2021). The study of Demirtas et al. (2022) explains that most proficient renewable energy usage is gained through geothermal, solar, wind, hydroelectricity, and biomass. Additionally, the optimal renewable energy consumption substitutes depend on PESTLE extents of geothermal and solar energies.

In the existing literature, some studies have contradicted the statement that RE consumption improves environmental quality. The study of Jebli and Youssef (2017) concluded that RE consumption increases environmental degradation in five selected MENA countries. They provided the reason for this relationship: RE consumption in these countries comprise flammable and waste materials. Therefore, the quality of renewable energy matters for environmental quality. The study of Adebayo (2021) reveals that renewable energy consumption has a negative but

insignificant impact on CO2 emissions in the short run and long run in the case of South Korea. Furthermore, their study also explains that globalization has a positive and significant impact on CO2 emissions in both the short run as well as long run. In addition, Jebli and Youssef (2015) concluded that RE consumption weakens environmental quality, whereas the use of non-RE significantly increases CO2 emissions in Tunisia. Based on the literature support, we propose the following hypothesis.

H2: REC improves ecological quality in South Asian developing economies.

2.3 Economic growth and environmental quality

In the existing literature, numerous studies are available on the relationship between EG and EQ. This relationship is straight or inverted U-shaped, which implies that in the early phase of economic progress, the countries focus more on EG and increasing output without caring for the natural environment. Due to this, environmental quality decreases at the initial stage of development. However, after satisfying EG, countries move toward environmental sustainability (Grossman and Krueger, 1991, Song et al., 2013). The U-shaped association between EG and ecological sustainability as environmental Kuznets Curve (EKC) by Panayotou (1993). The findings of the EKC hypothesis have mixed results; some researchers have concluded the U-shaped link between EG and ecological quality, while others have not found this relationship. Narayan and Narayan (2010) researched a panel of 43 emerging economies, and the empirical findings of their research confirmed that U-shaped inverted relationships exist in sampled countries. In particular, they concluded that the ecological condition improves in the long run as incomes increase. Other researchers, Pao and Tsai (2011), also investigated a similar relationship in the case of BRICS countries and empirically found that the EKC hypothesis exists in said countries. In the initial stage, as GDP increases in these countries, the environmental quality reduces while ecological quality improves when countries gain more economic growth.

Furthermore, Shokoohi et al. (2022) investigated the impact of energy intensity and economic growth on environmental quality in Middle East countries. Their findings show that economic growth increases CO2 emissions; however, there is a U-shaped inverted EKC hold in these countries. Moreover, Cho et al. (2014) investigated the link between income and ecological sustainability by taking a sample of 22 OECD countries. According to the findings of their study, the EKC hypothesis hold in these countries. In line with their study, Apergis and Ozturk (2015) analyzed the connection between EG and EQ in Asian countries. They used the GMM econometric technique for the analysis of panel data, and empirically verified the presence of EKC in selected Asian states. This study also verified a U-shaped relationship between EG and EQ.

On the contrary, other studies have not found the presence of EKC. In addition, Chandran and Tang (2013) investigated the relationship between energy consumption, FDI, and real GDP on panel data of ASEAN-5 economies. Their findings have not found the U-shaped link between

income and ecological quality. Thus, the EKC hypothesis in ASEAN-5 countries does not exist. However, some other studies have investigated a similar relationship in the case of different individual countries by using time series data.

The study of Ozturk and Acaravci (2010) does not find the presence of EKC in the case of Turkey. Their empirical outcomes confirmed that an increase in GDP does not impact EQ in the case of Turkey. Therefore, the U-shaped relationship between EG and EQ did not witness in Turkey. Similarly, Ozturk and Al-Mulali (2015) also tested the EKC hypothesis in Cambodia. Their outcomes found that the link between income and ecological quality has not been confirmed.

Moreover, some studies found mixed findings regarding the presence of the EKC hypothesis. Thompson (2012) investigated the EKC framework for water resources and pollution on panel data of 38 developed and developing economies. His findings showed that the cost of water pollution is lower in the case of excess water countries than in water shortage countries. Similarly, Sinha and Bhattacharya (2017) investigated the presence of EKC in different Indian cities and divided the data into two categories; that is, resident and industrial. According to their findings, the EKC results are mixed in both categories. The graph for the EKC curve is given in Figure 1, which shows that increasing economic growth spoils the natural environment. However, after achieving desired economic output, environmental degradation declined, as shown in Figure 1.

H3: Economic growth has a positive impact on CO2 emissions and EKC hold in South Asian countries.

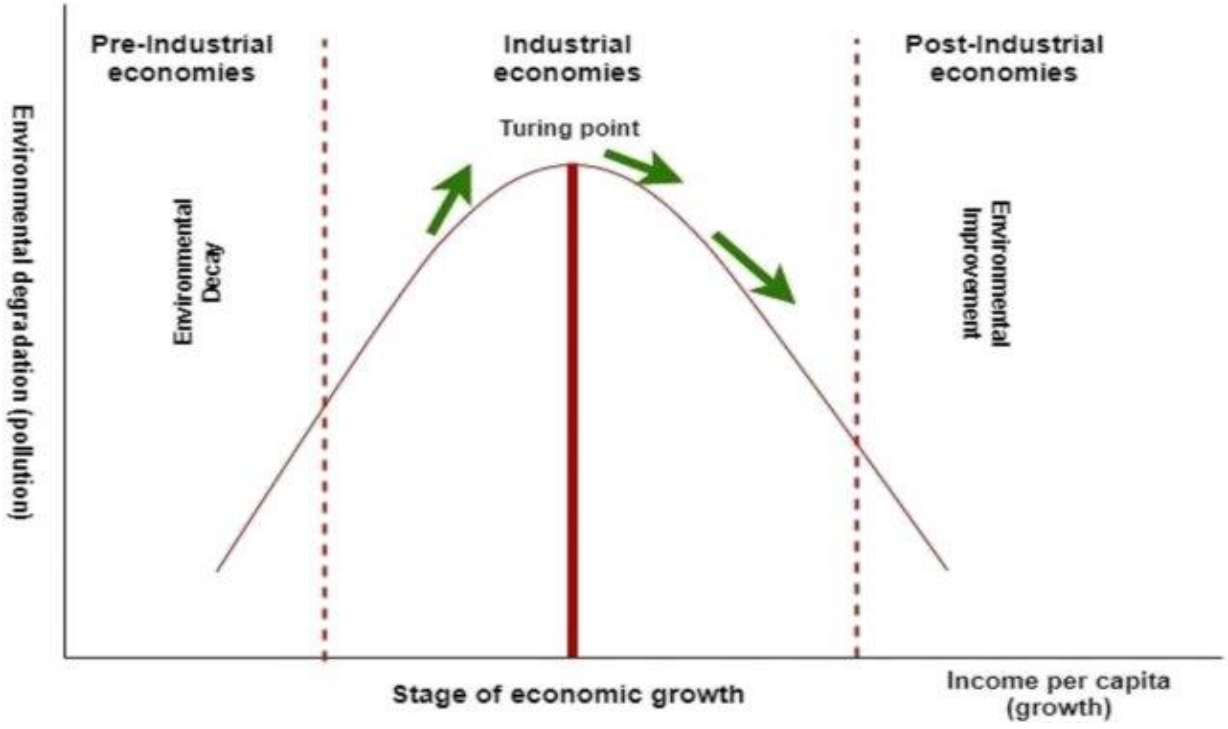


Figure 1: EKC Formulations (Source: Dinda, 2004)

3. Data and methodology

3.1 Model specification

Globalization, real GDP, and renewable energy consumption have remained important determinants of CO2 discharges (Pao and Tsai., 2011; Cho et al., 2014; Zafar et al., 2019a,b; Usman et al., 2020a; Charfeddine, 2017). Therefore, these variables could be the determinants of environmental quality in South Asian economies. We measured environmental quality for this study in the degree of CO2 emissions. More releases of CO2 lead to poor environmental quality and vice versa. The basic model for this study is as follows:

$$CO_{2i} = \int (EG,, GLN, REC) \ , \qquad (1)$$

where CO2 emissions represent environmental quality and are defined by real GDP proxy for economic growth (EG), globalization (GLN), and renewable energy consumption (REC). We converted equation 1 into linear form as given below:

$$CO_{2it} = \alpha_{it} + \beta_{it} EG_{it} + \delta_{it} GLN_{it} + \theta_{it} REC_{it} + \varepsilon_{it} \quad . \qquad (2)$$

The notions i and t specify the time (1990-2014), and cross-sections (South Asian countries), α_{it} and ε_{it} are regression slope and error term of the regression equation. Where β_{it}, γ_{it},δ_{it}, and θ_{it} are the coefficients of variables used for empirical analysis.

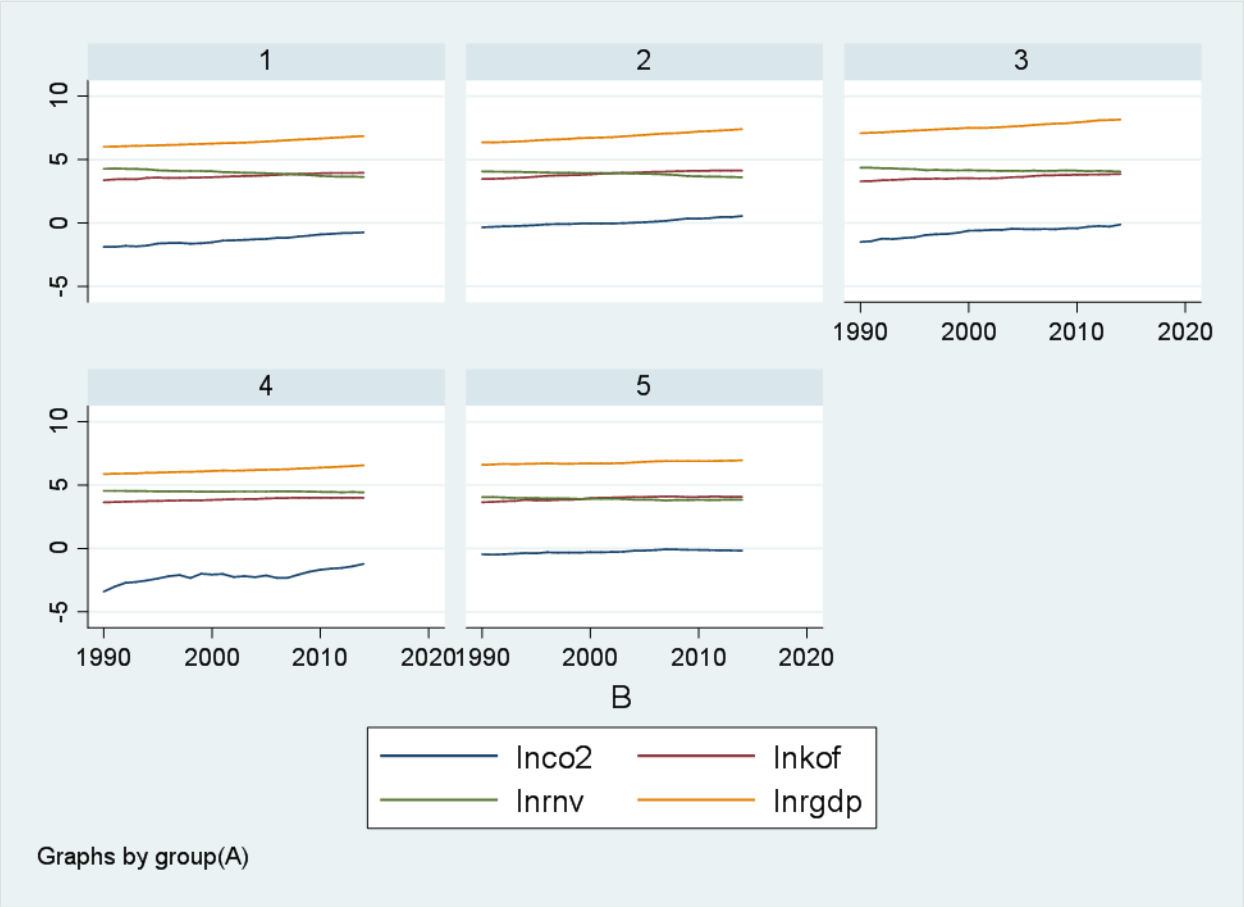
3.2 Data and variables

We used a panel of 5 South Asian developing countries, including; Bangladesh, India, Pakistan, Sri Lanka, and Nepal, from 1990 to 2014. The data for explained variable CO2 emission was obtainable up to 2014. Thus, the dataset of all variables was obtained from 1990 to 2014. The described variable for this investigation is CO2 emissions computed in metric tons per capita and is taken as a proxy for ecological quality. More releases of CO2 lead to poor environmental quality and vice versa. The data for CO2 discharges were obtained from World Bank (WDI, 2019).

The independent variables for this study are real GDP, globalization, and renewable energy consumption. We used data from the KOF index as a proxy for globalization and real GDP per capita (economic growth). Moreover, we used data as a percentage of RNC from overall energy use. Annual data for all variables have been gathered from World Bank (WB) from 1990 to 2014. The details of variable definitions, sources, and units are given in Table 1. Figure 1 shows the trend of the variables for five south Asian countries from 1990-2020. Figure 2 shows the trends of variables used in this study.

Table 1: Variables' measurements and definitions

Variable	Symbol	Measurement unit	Source
Co2 emission	CO2	Metric ton per capita	WDI
KOF index	GL	The range between 1 and 100	Database of KOF Swiss Economic Institute
Renewable Energy consumption	EC	% of total final energy consumption	WDI
Real GDP per capita	RGDP	GDP per capita (constant 2010 US$)	WDI



Note: 1=Bangladesh, 2=India, 3=Pakistan, 4=Sri Lanka, 5=Nepal, lnkof= globalization (log), lnrnv= renewable energy consumption (log), lnrgdp=economic growth (log), lnco2= CO2 emissions (log).

Figure 2 Trend of variables in five South Asian economies

Table 2 shows the results of descriptive statistics. According to the results, the mean and SD for CO2 emission are 0.56 and 0.38, respectively. The mean and SD of the globalization index are 45.55 and 9.58. Similarly, the mean and SD for renewable energy consumption are 61.72 and 16.68. Moreover, the mean and SD for real GDP are 1003.6 and 666.25. Please see Table 2 for details.

Table 2: Results of descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Co2 emission	125	0.560	0.384	0.033	1.727
KOF index	125	45.552	9.584	26.813	62.243
Renewable Energy consumption	125	61.728	16.689	36.651	95.119
Real GDP per capita	125	1003.65	666.252	354.257	3505.55

3.3 Empirical methodology

It is necessary to conduct tests for cross-sectional dependency, unit root, and cointegration tests of designed variables before analyzing the long-run relationship among variables (Hussain, Khan, et al., 2020). In the case of South Asian economies, the presence of cross-section dependence can be an issue. Therefore in this study, we first conduct a CD test if cross-sectional dependence is present in the data; then, we will conduct second-generation panel unit tests, i.e. CIPS and CADF unit root tests. Further, this study performed two different panel cointegration tests developed by Pedroni (1999) and Westerlund (2005). Finally, we will analyze the long-run relationship through panel FMOLS and DOLS.

3.3.1 Crossectional dependence (CD)

Recently in econometrics analysis, the question of cross-sectional dependence has been noticed from spillover effects, such as shock, unnoticed components, and spatial dependency, that can spill over hooked on a single state and influence long-term policy implications (Danish and Ulucak 2020). Consequently, without a CD test, the results can be biased and unpredictable (Dong et al., 2018). Due to mentioned concern arguments, we first test the data for the presence of CD (M. Pesaran 2004). The alternative describes that the cross-sectional dependency exists and vice versa.

3.3.2 Unit root tests

To check the stationarity condition of variables, we used different panel unit tests. These include Im-Pesaran-Shin (CIPS) test (Im, Pesaran, and Shin,1997) and the augmented Dickey-Fuller (CADF) test (Said and Dickey, 1984) in our study on the designated panel data. We employed second-generation unit tests because the "first-generation unit root" cannot report the cross-sectional dependency problems; if the variables are unified in the same order in both tests, the null hypothesis can be rejected.

3.3.3 Cointegration analysis

After checking the unit root condition, we conduct the cointegration tests among variables. We employed various residual-based panel cointegration tests given by Pedroni (1999) and Westerlund (2005). Westerlund's (2005) approach is valid in residual panel heterogeneity and CD; similarly, temporal dependence does not need to be corrected (Westerlund, 2005). To check the alternative hypotheses of the existence of cointegration, the following panel cointegration form is considered:

$$\rho_{it} = \mu_i \rho_{it-1} + \hat{\gamma}_{it} \, . \qquad (3)$$

Westerlund (2005) offers two variance ratio (VR) test statistics imitative from equation 3. These are statistics on panel variance ratio (PVR) and statistics on group mean-variance ratio (GVR). Both VR checks are grounded on Phillips et al. (1990) and (Breitung 2002).

3.3.4 Long-run estimators

After confirming the cointegration association among variables, we conduct the long-run link among explanatory and explained variables. To check the long-run relationship, we employ fully modified-OLS ($FMOLS$) given by Pedroni (2000). The following equation is used to estimate the FMOLS;

$$\hat{\gamma}_{FMOLS} = \left[\frac{1}{N}\sum_{i=1}^{N}\sum_{t=1}^{T}(J_{it} - \bar{J}_i)^2\right]^{-1} \times \left[\sum_{t=1}^{T}(J_{it} - \bar{J}_i)\hat{k}_{it} - T\hat{\partial}_{eu}\right] \qquad (4)$$

Where $J, \; and \; k$ are dependent and independent variables, $\hat{\partial}_{eu}$ is utilized to denote the Kernel estimator, which is responsible for the sequential association of the calculated value covariance term. Likewise, N and T are for the time and cross-sections in the equation. The $FMOLS$ can potentially remove heteroscedasticity by letting data from the procedures of Bartlett and Kernel (Kiefer and Vogelsang 2002). Also, the $FMOLS$ $\hat{\partial}_{eu}$ term handles potential endogeneity and autocorrelation problem and provides robust results (Funk and Strauss 2000). Furthermore, FMOLS can eliminate small sample bias. However, it cannot deal with the problem of cross-sectional CD, but it can estimate cointegrated panels (Ozturk and Al-Mulali 2015). Besides FMOLS, we used dynamic OLS ($DOLS$) as a second estimator (Stock and Watson 1993). It permits substitute order variables to be incorporated and deals with the simultaneity between independent variables. According to Stock and Watson (1993), $DOLS$ is beneficial, specifically in small samples, compared to other long-run estimators.

4. Results and Discussion

This investigation aimed to analyze the theoretical and empirical link of GLN, REC, and EG with ecological quality. The data set of five south Asian economies was analyzed through different econometric techniques. We conducted CD tests, panel unit root tests, and various cointegration tests, and finally, we employed FMOLS and DOLS for long-run relationship testing.

4.1 Results of Cross-sections dependency test

The outcomes from the CD check are provided in Table 3. According to the results, the alternative hypothesis was accepted at 1% significance, determining that CD exists in our data set.

Table 3 Results of Cross-sections dependency test

Variable	**CD-test**	**p-value**	**Corr**	**abs(corr)**
Co2 emission	13.97***	0.000	0.883	0.883
Globalization	15.14***	0.000	0.958	0.958
Renewable Energy consumption	13.29***	0.000	0.841	0.841
Economic growth	15.53***	0.000	0.982	0.982

4.2 Results of panel unit root tests

Since we confirmed the presence of CD in our data, we use second-generation unit root tests such as CIPS and CADF tests to check the stationary condition in our data. The findings of mentioned tests are given in Table 4. The outcomes indicate that CO2 emissions, globalization, and RE consumption are stationary at first difference while real GDP is stationary at both level and first difference in the CADF test. Similarly, CIPS unit root test results state that all variables are stationary at first difference.

Table 4 CADF & CIPS tests of unit roots

Variable	***CADF***		***CIPS***	
	Level	***1st-difference***	***Level***	***1st-difference***
CO_2	-1.489	-5.058*	0.913	-2.480**
GL	-1.430	-4.236*	-1.139	-3.548*
EC	-1.630	-4.508*	-1.356	-2.378***
RGDP	-2.243**	-4.555*	-1.740	-3.343*

Note: *, ** &*** indicate the level of significance at 1% ,5%, and 10%.

4.3 Results of panel cointegration

After checking CD and unit tests, conducting long-run cointegration tests is necessary. To check long-run cointegration, we employed two cointegration tests developed by Pedroni (1999), and Westerlund (2005). Table 5 shows the results of the Westerlund cointegration test. Results described that there is significant long-run cointegration between dependent and independent variables.

Table 5 Results of Westerlund cointegration

Statistic	Value	Z-Value	P-value
Gt	-2.522**	1.774	0.038
Ga	-11.797*	1.427	0.077
Pt	-5.645**	2.06	0.02
Pa	-5.333	0.377	0.353

Note: significance at *** p<0.01, ** p<0.05, * p<0.1

Moreover, the Pedroni cointegration test results match with the Westerlund cointegration results as our variables are significantly cointegrated (see Table 6).

Table 6 Results of Pedroni cointegration tests

	Statics	P-value
Modified Phillips-Perron t	0.3082	0.379
Phillips-Perron t	-4.2239***	0.000
Augmented Dickey-Fuller t	-3.872***	0.0001

Note: significance at *** p<0.01, ** p<0.05, * p<0.1

4.4 Results of FMOLS and DOLS estimations

We confirmed the cointegration among variables. Therefore, we estimated the long-run association among the designed variables of this investigation. We used FMOLS and DOLS techniques to check the long-run link between globalization, renewable energy consumption, and economic growth with ecological quality. The results of FMOLS indicate that GLN reduces ecological eminence in the case of South Asia with a coefficient value of 0.230 and significant at 1%. However, RNC reduces CO2 releases and significantly mends ecological value in these countries with a coefficient value of -2.155 and significant at 1%.

Furthermore, real GDP also has a positive and significant relation with CO2 discharges in these countries, indicating that increased economic growth in these economies reduces ecological quality. However, empirical results confirmed that $RGDP^2$ is negatively and significantly related to CO2 releases, which specifies that the EKC hypothesis hold in these countries. Moreover, the empirical outcomes of DOLS estimation are almost similar to those of FMOLS (see Table 7). The

findings of this study are consistent with the findings of Sabir and Gorus (2019) and Xue et al. (2021a,b).

Table 7 Results of Panel FMOLS and DOLS

Dependent variable= CO_2 emissions		
Variable	**FMOLS**	**DOLS**
GL (log)	0.230***(0.0032)	0.298***(0.133)
RE (Log)	-2.155***(0.0049)	-2.457***(1.859)
RGDP (log)	1.529 ***(0.0012)	1.859***(0.291)
$RGDP^2$ (Log)	-0.070*** (3.52)	-0.097 ***(0.022)
R^2	0.813	0.80

Note: *=p<10%, **=p<5%, and ***=p<1%

Developing countries are mostly Fossil fuel-dependent, the leading cause of environmental degradation in developing economies. Similarly, South Asian countries are also non-renewable energy dependent; therefore, these countries are facing severe environmental contamination. Developing countries aim to achieve desired EG, which needs energy EC in production. Thus, inefficient usage of ecological assets has caused to increase in ecological contamination. This study provides empirical evidence that growing EG spoils the natural environment in South Asian economies. This study found the U-shaped association between EG and environmental sustainability, which determines the confirmation of EKC presence in South Asian developing economies. Recently the use of alternative energies has increased globally due to increased pressure from domestic and international stakeholders regarding environmental concerns. The conclusions of this investigation confirmed that REC improves ecological quality in South Asian economies. The research findings support the argument from Xue et al. (2021a) who use REC improves ecological conditions in South Asian countries and the EKC hypothesis in these countries. Different studies have found a positive relation between REC and EQ (Rahman and Vu, 2020; Bilgili et al., 2015; Hasnisah et al., 2019; Usman et al., 2020).

Moreover, this study empirically confirmed that GLN increases ecological pollution in South Asian countries. GLN has fostered industrialization, which has caused to increase the industrial waste and polluted the natural environment in the shape of air, water, and land pollution. Due to weak enforcement of environmental regulations, the GLN in developing economies has increased the growth of environmentally polluting industries (Copeland and Taylor 2004). GLN increases energy demand in countries, affecting the natural environment (Charfeddine, 2017). Moreover, GLN reduces environmental quality through non-REC. Non-REC increases CO2 and other hazardous gas emissions, which reduces air quality (Ahmed et al., 2016).

Moreover, GLN allows trade openness which increases the imports and exports of products and services and ultimately negatively impacts ecology (Dean, 2002). In addition, the study of

McAusland (2008) also provides evidence that trade reduces EQ. Therefore, globalization has been proven to be negatively related to ecological quality in the case of South Asian economies.

5 Conclusion

Like other developing economies, South Asian countries including Bangladesh, India, Nepal, Pakistan, and Sri Lanka, face severe environmental issues. The major contributors to environmental degradation in these countries include the use of non-renewable energy in industry, transport, and houses, increased population, and rapid urbanization. Working in this direction, this research investigates the relationship between GLN, RNC, and EG environmental quality in South Asian countries. For this purpose, we used a panel data sample from 1990 to 2014 and different econometric techniques to examine the association between variables. We conducted CD tests, second-generation panel unit root tests, and long-run cointegration tests, including the tests developed by Pedroni (1999), Kao (1999), and Westerlund (2005) in the study. The results of cointegration tests in our study confirmed the long-run cointegration among the variables used in this study. Finally, we employed the latest techniques, FMOLS, and DOLS, to test the long-run association between explained and explanatory variables. The results from FMOLS indicate a significant and positive relationship between globalization and ecological quality with a coefficient value of 0.230. Similarly, EG is also positively related to CO2 emissions with a coefficient value of 1.529. Moreover, the results in our study confirmed that the EKC hypothesis exists in these economies, which means that an increase of a unit of the square of GDP reduces 25% of the CO2 emissions. Moreover, consumption of renewable energy significantly reduces CO2 emissions in South Asian economies with a coefficient value of -2.155. The results from the DOLS model also support the results of FMOLS.

5.1 Policy Implications

From the findings of our paper, one could infer that the governments in South Asian countries should emphasize the manufacturing industries to adopt modern environmentally friendly methods of production to control the environmental degradation in the countries. These countries' governments should also promote the use of renewable energy in industries, houses, and transport. Green innovation should be promoted with assistance from both financial and non-financial governments. Governments should also increase taxes on non-renewable energies such as fossil fuels and provide subsidies on alternative energies. Moreover, the governments should make and enforce strict environmental regulations for both domestic and foreign investors to ensure the environmental-friendly globalization process.

5.2 Limitations and future research directions

This study is conducted in South Asian developing countries and the data used for analysis is up to 2014. Thus, further studies could be conducted on a similar topic in developing countries of other regions and using more updated data in the analysis. Also, a comparative study could also be conducted on developed and developing economies on the same topic. In this paper, we apply different econometric techniques to investigate the relationship between GLN, RNC, and EG environmental quality in South Asian countries. Extensions of our work could apply the tools used in our paper to study many issues, for example, economic risk (Adebayo, et al., 2022), Monetary Policy Uncertainty (Aor, et al., 2021), energy (Lean, et al., 2010; Cheng, et al., 2013; Alghalith, et al., 2017; Esmaeil, et al., 2020), economic growth (Lv, et al., 2019; Chang, et al., 2022), exchange rate (Ramzan, 2021), emerging markets (Singh, et al., 2022), and many others. Academics and practitioners could use other advanced tools, see, for example, Tiku, et al., 2000; Bai, et al., 2009) to analyze the issue studied in our paper.

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