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Growth, Foreign Direct Investment And Environmental Outcomes In South Asian Economies

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Abstract

This study investigates the relationship between economic growth, foreign direct investment, energy consumption and environmental degradation in South Asian countries over the period 1997–2022. Using balanced panel data for eight countries and employing a fixed effects estimation approach, carbon dioxide emissions are used as a proxy for environmental degradation. The results provide robust evidence in support of the Environmental Kuznets Curve hypothesis, revealing an inverted U-shaped relationship between economic growth and carbon emissions. Economic growth, foreign direct investment, non-renewable energy consumption and trade openness are found to exacerbate environmental degradation, whereas renewable energy consumption significantly reduces carbon emissions. These findings suggest that economic expansion and investment-led growth in South Asia have occurred largely at the expense of environmental quality. The study highlights the importance of strengthening environmental regulations, promoting renewable energy adoption and guiding foreign investment toward environmentally sustainable activities to achieve long-term sustainable development in the region.

Keywords: Economic Growth, Foreign Direct Investment, Carbon Emissions, Environmental Kuznets Curve, Fixed Effect Model.

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Introduction

Environmental deterioration has emerged as a major concern for the global community, particularly for developing economies striving for rapid economic expansion. The pursuit of higher economic output often relies on energy-intensive production, industrial activities, and natural resource exploitation, which place considerable pressure on environmental systems. Human-induced activities such as industrialization, deforestation, excessive fossil fuel use, and rising energy consumption have significantly increased greenhouse gas emissions, thereby intensifying climate change and global warming. The accumulation of carbon dioxide (CO_2), methane, and nitrous oxide in the atmosphere has contributed to rising global temperatures and heightened environmental vulnerability.

In recent decades, global greenhouse gas emissions have increased markedly, with carbon dioxide accounting for the largest proportion of total emissions. This trend is particularly evident in developing regions, where rapid industrial growth, urban expansion, population growth, and rising energy demand have accelerated emission levels. While economic growth improves income levels, employment opportunities, and living standards, it frequently occurs at the expense of environmental quality in countries where environmental regulations and enforcement mechanisms remain weak.

Environmental degradation refers to the continuous decline in environmental quality resulting from unsustainable economic and human activities. It manifests through air and water pollution, soil degradation, ecosystem disruption, and biodiversity loss, all of which pose serious risks to public health and long-term sustainable development. For developing economies, the central challenge lies in achieving sustained economic growth while limiting environmental damage and ensuring ecological sustainability.

South Asian developing countries—including Pakistan, India, Bangladesh, Sri Lanka, Nepal, Bhutan, Maldives, and Afghanistan—have experienced substantial economic transformation over the past few decades. Increased foreign direct investment, expanding trade openness, rapid urbanization, and growing energy consumption have contributed significantly to economic development in the region. However, heavy reliance on non-renewable energy sources, inadequate adoption of clean technologies, and weak environmental governance have intensified environmental degradation across South Asia.

Foreign direct investment plays a vital role in economic development by facilitating capital inflows, employment generation, and technology transfer. Nevertheless, its environmental implications remain uncertain. While foreign investment can promote cleaner production methods and energy-efficient technologies, it may also increase pollution if multinational firms relocate environmentally intensive activities to countries with less stringent environmental regulations. Similarly, economic growth raises energy demand, particularly from fossil fuels, leading to increased carbon emissions.

The relationship between economic growth and environmental degradation is commonly analyzed through the Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis proposes an inverted U-shaped relationship, suggesting that environmental degradation increases during the early stages of economic development but declines after a certain income threshold is reached. At higher income levels, economies tend to adopt cleaner technologies, enforce stricter environmental regulations, and prioritize environmental quality.

Although extensive empirical literature exists on the growth–environment nexus, findings remain inconclusive, particularly for developing regions. Moreover, limited studies focus specifically on South Asian developing countries using recent data while simultaneously examining the roles of foreign direct investment, renewable energy consumption, and non-renewable energy consumption within the EKC framework. Addressing this gap is essential for understanding the region's environmental dynamics and designing effective policy interventions.

Accordingly, this study investigates the impact of economic growth, foreign direct investment, renewable energy consumption, and non-renewable energy consumption on carbon emissions in South Asian developing countries over the period 1997–2022. Using panel data econometric techniques, the study examines the validity of the Environmental Kuznets Curve hypothesis and identifies the key drivers of environmental degradation in the region. The findings aim to provide updated empirical evidence and offer policy-relevant insights to support sustainable development strategies in South Asia.

Problem Statement

Despite sustained economic growth and increasing foreign direct investment in South Asian developing countries, environmental degradation—particularly carbon emissions—has continued to rise. The region remains heavily dependent on fossil fuels, while the adoption of renewable energy and environmentally friendly technologies remains limited. Existing empirical studies provide mixed evidence regarding the environmental effects of economic growth and foreign direct investment, and few studies incorporate energy structure within an Environmental Kuznets Curve framework using recent panel data. Consequently, there is insufficient empirical evidence to guide policymakers in balancing economic growth with environmental sustainability in South Asia.

Research Questions

Does economic growth contribute to environmental degradation in South Asian developing countries?
Does the Environmental Kuznets Curve hypothesis hold for South Asia during the period 1997–2022?
What is the impact of foreign direct investment on carbon emissions in the region?
How do renewable and non-renewable energy consumption affect environmental degradation in South Asian developing countries?

Objectives of the Study

The main objectives of this study are to:
Examine the relationship between economic growth and carbon emissions in South Asian developing countries.
Test the validity of the Environmental Kuznets Curve hypothesis for the region.
Analyze the environmental impact of foreign direct investment.
Assess the roles of renewable and non-renewable energy consumption in determining carbon emissions.
Provide policy recommendations to promote sustainable economic growth while reducing environmental degradation.

Significance of the Study

This study contributes to the existing literature in several important ways. First, it provides updated empirical evidence on the Environmental Kuznets Curve hypothesis for South Asia using recent panel data. Second, it simultaneously examines the combined effects of economic growth, foreign direct investment, and energy structure on environmental degradation. Third, the findings offer practical policy implications for governments seeking to achieve sustainable development by promoting renewable energy adoption, regulating foreign investment, and reducing dependence on fossil fuels. The study is particularly valuable for policymakers, environmental planners, and researchers concerned with climate change mitigation and sustainable economic development in South Asia.

Literature Review

This section reviews the empirical literature related to the relationship between economic growth, foreign direct investment, energy consumption and environmental degradation. The review is structured into two subsections. The first subsection focuses on the relationship between economic growth and environmental degradation, while the second examines the link between foreign direct investment and environmental degradation. The purpose of this review is to identify gaps in the existing literature and position the present study within the broader academic debate.

Economic Growth and Environmental Degradation

The relationship between economic growth and environmental degradation has been extensively analyzed in both developed and developing economies. A large body of empirical literature is grounded in the Environmental Kuznets Curve (EKC) hypothesis, which proposes an inverted U-shaped relationship between income growth and environmental pollution (Grossman & Krueger, 1995). According to this hypothesis, environmental degradation increases during the early stages of economic development due to industrialization and increased energy consumption, but declines after a certain income threshold as cleaner technologies, environmental awareness and regulatory frameworks improve. Early empirical evidence supporting the EKC hypothesis was provided by Grossman and Krueger (1995), who found an inverted U-shaped relationship between income and several air pollutants. Subsequent studies, such as Selden and Song (1994) and Panayotou (1997), further confirmed the EKC hypothesis across different environmental indicators and country groups. These studies suggest that economic growth initially intensifies environmental pressure but eventually contributes to environmental improvement once countries reach higher income levels.

Several studies focusing on developing and emerging economies also support the EKC hypothesis. For example, Shahbaz et al., (2013) and Apergis and Payne, (2014) report evidence of an inverted U-shaped relationship between economic growth and carbon emissions in developing countries. Similarly, Al-Mulali, Saboori, and Ozturk (2015) find that economic growth increases carbon emissions in the short run but reduces them in the long run as income levels rise. However, empirical findings on the EKC hypothesis are not uniform. Some studies fail to confirm the inverted U-shaped relationship and instead report a monotonic positive relationship between economic growth and environmental degradation. For instance, Narayan and Narayan (2010) and Stern (2004) argue that economic growth alone does not necessarily lead to environmental improvement, particularly in countries with weak institutional quality and ineffective environmental governance. These studies suggest that without supportive environmental policies, economic growth continues to exert pressure on natural resources and environmental quality.

Energy consumption has been identified as a critical factor in the growth–environment nexus. Numerous studies show that non-renewable energy consumption, including coal, oil, and natural gas, significantly increases carbon emissions and environmental degradation (Sadorsky, 2009; Ozturk & Acaravci, 2010). In contrast, renewable energy consumption has been found to mitigate environmental damage by reducing reliance on fossil fuels (Pao & Fu, 2013; Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016). Empirical evidence indicates that economies with higher shares of renewable energy experience lower carbon emissions even during periods of economic expansion. Recent panel data studies employing advanced econometric techniques, such as fixed effects, dynamic panel models and cointegration approaches, reveal mixed results regarding the growth–environment relationship (Destek & Sarkodie, 2019). While some studies confirm the EKC hypothesis, others find U-shaped, N-shaped or insignificant relationships. These inconsistencies highlight the importance of country-specific characteristics, energy structure and policy frameworks in shaping environmental outcomes.

Overall, the literature suggests that economic growth can either exacerbate or alleviate environmental degradation depending on the stage of development, energy composition and institutional quality. This underscores the need for region-specific analysis, particularly for South Asian developing countries, where rapid economic growth and environmental challenges coexist.

Foreign Direct Investment and Environmental Degradation

Foreign direct investment is widely recognized as a key driver of economic growth, technological progress and industrial development. However, its environmental consequences remain highly debated in the literature. Two competing hypotheses dominate this debate: the Pollution Haven Hypothesis (PHH) and the Pollution Halo Hypothesis. The Pollution Haven Hypothesis argues that multinational firms relocate pollution-intensive activities to countries with weak environmental regulations, leading to increased environmental degradation in host economies (Copeland & Taylor, 2004). Empirical studies supporting this hypothesis find that foreign direct investment inflows are positively associated with carbon emissions in developing countries (Cole, Elliott, & Zhang, 2017). These studies suggest that lax environmental standards encourage foreign investors to engage in environmentally harmful production activities.

In contrast, the Pollution Halo Hypothesis posits that foreign direct investment can improve environmental quality by facilitating the transfer of cleaner technologies, advanced production methods and better management practices (Eskeland & Harrison, 2003). According to this view, multinational firms often adhere to higher environmental standards and contribute to reduced emissions in host countries. Empirical evidence supporting the pollution halo effect is more commonly observed in middle and high-income countries with stronger regulatory frameworks (Zarsky, 1999). Empirical findings on the FDI–environment relationship are mixed. While some studies report a positive relationship between foreign direct investment and carbon emissions (Pao & Tsai, 2011; Omri, Nguyen, & Rault, 2014), others find a negative or insignificant impact (Tang & Tan, 2015). These divergent results are largely attributed to differences in economic structure, environmental regulations, energy consumption patterns and levels of technological development across countries.

Several studies emphasize the role of energy consumption as a mediating factor in the FDI–environment nexus. Foreign direct investment that relies heavily on non-renewable energy sources tends to increase carbon emissions, whereas FDI directed toward renewable energy and environmentally friendly sectors can reduce environmental degradation (Salahuddin et al., 2018). This indicates that the environmental impact of FDI depends not only on its volume but also on its sectoral composition. In the context of South Asia, empirical evidence remains limited. Most existing studies focus on single-country analyses or exclude energy structure variables, leaving a gap in understanding the combined effects of economic growth, foreign direct investment, renewable energy and non-renewable energy consumption on environmental degradation. Addressing this gap is essential for designing effective policies that promote sustainable development in the region.

Theoretical Framework

The theoretical foundation of this study is based on the Environmental Kuznets Curve (EKC) hypothesis, which postulates an inverted U-shaped relationship between economic growth and environmental degradation. In the early stages of development, economic expansion increases pollution due to industrialization and fossil-fuel-based energy consumption. At later stages, higher income levels promote cleaner technologies, stricter environmental regulations and improved environmental awareness, leading to reduced emissions.

Foreign direct investment may influence environmental quality through two competing mechanisms. Under the pollution haven hypothesis, FDI increases pollution in countries with weak environmental regulations. Conversely, the pollution halo hypothesis suggests that FDI improves environmental quality by introducing advanced technologies and efficient production practices. Energy consumption further mediates these relationships, as non-renewable energy increases emissions, while renewable energy mitigates environmental damage.

Literature Gap and Contribution

Based on the reviewed literature, three key gaps are identified. First, empirical evidence on the Environmental Kuznets Curve hypothesis remains inconclusive for South Asian developing countries, particularly when recent data are considered. Second, limited studies incorporate both renewable and non-renewable energy consumption while examining the joint impact of economic growth and foreign direct investment on environmental degradation. Third, few studies provide a comprehensive panel analysis covering multiple South Asian countries over an extended period. The present study addresses these gaps by examining the impact of economic growth, foreign direct investment, renewable energy consumption and non-renewable energy consumption on carbon emissions in South Asian developing countries from 1997 to 2022. By employing panel data techniques, this research contributes to the existing literature and provides policy-relevant insights for sustainable development in the region.

Data and Methodology

This chapter explains the data sources, variable selection, model specification and econometric methodology used to examine the relationship between economic growth, foreign direct investment, energy consumption and environmental degradation in South Asian developing countries.

Data Description and Sources

The study employs balanced panel data covering eight South Asian developing countries, namely Pakistan, India, Bangladesh, Sri Lanka, Nepal, Bhutan, Maldives and Afghanistan, over the period 1997–2022. The selection of countries is based on data availability and their relevance to the research objectives.

Environmental degradation is proxied by carbon dioxide (CO_2) emissions, which is widely used in empirical studies as an indicator of environmental pressure. Economic growth is measured by gross domestic product (GDP). To test the Environmental Kuznets Curve (EKC) hypothesis, the square of GDP (GDP^2) is included in the model. Foreign direct investment (FDI) is incorporated to capture the impact of international capital inflows. Energy structure is represented by renewable energy consumption (REC) and non-renewable energy consumption (NREC). Trade openness (TO) is included as a control variable.

Table 1: Descriptions and Measurement of Variables

Sr. #	Variables	Description	Measurement	Sources
1	**EN**	Environmental Degradation	CO_2 Emission Per Capita	WDI
2	**TO**	Trade Openness	% of GDP	WDI
3	**FDI**	Foreign Direct Investment	Inflow, % of GDP	WDI
4	**GDP**	Economic Growth	GDP, Per Capita	WDI
5	**GDP^2**	Square of Economic Growth	GDP^2, Per Capita	WDI
7	**REC**	Renew Energy Consumption	%age of Total consumption	US-EIA
9	**NREC**	Nonrenewable energy consumption	%age to Total consumption	US-EIA

Source: World Bank, US-EIA

All data are obtained from internationally recognized secondary sources, primarily the World Development Indicators (WDI) and International Energy Agency (IEA) databases, ensuring reliability and consistency across countries and over time.

Variable Definition

CO_2: Carbon dioxide emissions (metric tons per capita), representing environmental degradation
GDP: Gross domestic product, proxy for economic growth
GDP^2: Square of GDP, used to test the EKC hypothesis
FDI: Foreign direct investment inflows (% of GDP)
REC: Renewable energy consumption (% of total energy consumption)
NREC: Non-renewable energy consumption (% of total energy consumption)
TO: Trade openness, measured as the sum of exports and imports as a percentage of GDP

Model Specification

Based on the theoretical framework and existing literature, the functional form of the model is expressed as:

$$CO2 = f(TO, FDI, GDP, GDP^2, REC, NREC)$$

The corresponding econometric model is specified as:

$$CO2_{it} = \beta_0 + \beta_1 TO_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 GDP_{it}^2 + \beta_5 REC_{it} + \beta_6 NREC_{it} + \varepsilon_{it}$$

where i represents the country and t denotes the time period.
An inverted U-shaped EKC relationship is confirmed if $\beta_3 > 0$ and $\beta_4 < 0$.

Econometric Methodology

Given the panel structure of the data, this study employs panel data estimation techniques. Both Fixed Effects (FE) and Random Effects (RE) models are initially considered. The fixed effects model controls for unobserved, time-invariant country-specific characteristics that may influence carbon emissions, such as institutional quality, geography and long-standing policy differences.
The fixed effects model is specified as:

$$CO2_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it}$$

where α_i captures country-specific fixed effects and X_{it} represents the vector of explanatory variables.
The random effects model assumes that individual effects are random and uncorrelated with the explanatory variables. To select the appropriate model, the Hausman test is employed. A ensure that the chosen model provides consistent and unbiased estimates.

Diagnostic Tests

Several diagnostic tests are conducted to validate the model: Multicollinearity is examined using the correlation matrix and Variance Inflation Factor (VIF), Autocorrelation is tested using the Breusch–Godfrey LM test, Heteroskedasticity is examined using the Breusch–Pagan–Godfrey test.
These tests ensure the robustness and reliability of the estimated results.

Estimation Strategy

Based on the Hausman test results, the Fixed Effects model is selected as the preferred estimation technique. This approach is appropriate given the presence of country-specific characteristics that may correlate with the explanatory variables. The fixed effects model provides consistent estimates and allows for meaningful interpretation of the relationship between economic growth, foreign direct investment, energy consumption and environmental degradation in South Asian developing countries.

Results and Analysis

This chapter presents the empirical results obtained from panel data estimation and provides a detailed interpretation of the findings. The analysis focuses on the existence of the Environmental Kuznets Curve (EKC) hypothesis and the impact of economic growth, foreign direct investment, trade openness and energy consumption on carbon emissions in South Asian developing countries.

Descriptive Statistics

Table 2 presents the descriptive statistics of the variables used in the analysis for South Asian developing countries over the period 1997–2022. The results show considerable variation across countries and over time, particularly in carbon emissions, trade openness and energy consumption. Such variation supports the suitability of panel data estimation. The Jarque–Bera statistics indicate deviations from normality, which is common in macroeconomic panel data.

Table 2: Results of Descriptive Statistics of Key Variables in Model 2 (Panel Data 1997 to 2022)

	CO2	TO	FDI	GDP	GDP2	NREC	REC
Mean	0.883965	56.32049	1.808839	4.62247	90.45563	3.070111	49.66025
Median	0.64014	45,67698	0.879492	3.95537	17.24263	0.161645	49.1272
Maximum	3.963267	165.9793	16.78347	95.12175	9048.146	31.78274	93.4556
Minimum	0.054867	-0.02947	-0.63881	-34.6791	0.003649	0.004199	0.254622
Std. Dev.	0.81712	39.30676	2.719906	8.331251	624.658	7.183608	27.74394
Skewness	1.692142	0.922218	2.98513	5.664748	13.7881	2.749169	-0.0647
Kurtosis	5.722969	2.996993	12.59816	68.53072	197.6666	9.455864	2.100544
Jarque-Bera	169.8114	30.6178	1149.918	39803.7	347899.8	647.1891	7.43188
Probability	0.000000	0.000000	0.000000	0.0000	0.000000	0.000000	0.024333
Sum	190.9365	12165.23	390.7093	998.4536	19538.42	663.1439	10726.61
Sum Sq. Dev.	143.5523	332179.6	1590.545	14923.09	83892492	11094.91	165491.2
Observations	216	216	216	216	216	216	216

Source: Author's Calculations

Diagnostic Test:

Analysis of Multicollinearity

When there is relationship between independent variables in a regression model this problem is called Multicollinearity. If the explanatory variables are strongly correlated with each other there will be perfect multicollinearity between the variables. The value of coefficient correlation is -1 to +1. If the value is close to 1 there will be perfect collinearity between the variables. In this model we use pair wise correlation matrix and variation inflation factor (VIF) to check the multicollinearity.

Pair-Wise Correlation Matrix

Table 3 reports the pair-wise correlation matrix of the variables. Carbon emissions are positively correlated with trade openness, foreign direct investment, economic growth, and non-renewable energy consumption, while renewable energy consumption shows a negative correlation with emissions. None of the correlation coefficients exceed commonly accepted thresholds, indicating the absence of severe multicollinearity.

Table 3: Results of Pair – Wise Correlation Matrix of all Variables in Model 2

	CO2	**TO**	**FDI**	**GDP**	**GDP^2**	**NREC**	**REC**
CO2	**1**						
TO	0.70435	**1**					
FDI	0.76997	0.57993	**1**				
GDP	0.13072	0.05890	0.17765	**1**			
GDP^2	0.29577	0.15730	0.31282	0.75129	**1**		
NRE	0.21229	-0.16651	-0.0454	0.02595	-0.0256	**1**	
REC	-0.5051	-0.11975	-0.5374	-0.0792	-0.1630	-0.1433	**1**

Source: Author's Calculations

The correlation between FDI and TO is 0.57993 which shows there is strong correlation between variables. The correlation between GDP and TO is 0.05890 which is positive but shows weak correlation between gross domestic product and trade openness. The correlation between GDP^2 and TO is 0.15730, the correlation between NREC and REC is -0.16651 and -0.11975 which is negative. The correlation between GDP and GDP^2 with FDI is o.17765, 0.31282 and 0.10506 which shows the weak correlation. But the correlation between NREC and REC with FDI is -0.04454 and -0.10506. The correlation between NREC and REC with GDP2 is negative which is -0.0256 and -0.1630 and correlation between GE and GDP2 is 0.02818. The correlation coefficient of REC with NREC is -0.1433.

Variance Inflation Factor:

Through variance inflation factor we can detect the multicollinearity in the regression model. Variance inflation factor calculates the collinearity in the model for the predictors. Variation inflation factor tells us how much variance is inflated due to collinearity in the model. The value of variation inflation factors lies between 1 to 10. If VIF is equal to 1 there is no multicollinearity, if the value of VIF is between 1 to 5 there is low multicollinearity between the variables. If the value of VIF is greater than 5 or close to 10 there is severe problem of multicollinearity in the regression model.

Table 4: Results of Variance Inflation Factor (VIF) of all Variables in Model 2

Variance Inflation Factor (VIF)	
Variables	**Centered VIF**
TO	5.06217
FDI	3.09084
GDP	2.36739
GDP2	2.532317
NREC	1.572416
REC	1.610974
C	NA

Source: Author's Calculations

Table 4 presents the Variance Inflation Factor (VIF) results. All explanatory variables have VIF values below the conventional threshold of five, indicating that multicollinearity is not a serious concern in the model.

Analysis of Autocorrelation:

When there is relationship between variables current periods and previous period. When there is relationship between error term and other variables. Autocorrelation mostly exist is time series data. The value of autocorrelation shows that if it is +1 there will be positive autocorrelation and if the value is -1 there is negative autocorrelation in the data set. In this model used LM test to detect the autocorrelation in the data set. The hypothesis of autocorrelation is as follows:

Null Hypothesis(H_0) = no autocreation

Alternate Hypothesis(H_1) = autocreation

If the probability value is insignificant and greater than 0.05% so we will accept the null hypothesis its mean there is no autocorrelation. If the probability value is significant and less than 0.05% so we will accept the alternate hypothesis its mean there is problem of autocorrelation.

Table 5: The Results of Serial Correlation LM test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	16.66671	**Prob. F (2,204)**	0.2746
Obs*R-squared	30.1966	**Prob. Chi-Square (2)**	0.4631

Source: Author's Calculations

Table 5 reports the results of the Breusch–Godfrey LM test for serial correlation. The probability values are statistically insignificant, indicating the absence of autocorrelation in the model.

Analysis of Heteroskedasticity:

If the variance of residual is unequal there will be problem of heteroskedasticity. If we omitted a variable that can affect the dependent variable, of the functional form is not correct, if there are outliers in the data set, we can face the problem of heteroskedasticity. If there is problem of heteroskedasticity in the data set there, will be it will affect the accuracy of the model. So here we used Breush Pagan Godfrey test to detect the problem of heteroskedasticity. The hypothesis of Heteroskedasticity is as follows

Null Hypothesis (H_0) =No Heteroskedasticity

Alternate Hypothesis (H_1) = Heteroskedasticity

If the probability value is insignificant and greater than 0.05%, we will accept null hypothesis it's mean that there is no problem of Heteroskedasticity. If the probability value is significant and less than 0.05%, we will accept alternate hypothesis it means that there is problem of Heteroskedasticity.

Table 6: The Results of Breusch-Pagan-Godfrey test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	17.37496	**Prob. F(8206)**	0.351
Obs*R-squared	86.62308	**Prob. Chi-Square (8)**	0.2119
Scaled explained SS	888.6961	**Prob. Chi-Square (8)**	0.2565

Source: Author's Calculations

Table 6 presents the results of the Breusch–Pagan–Godfrey test. The insignificant probability values indicate that heteroskedasticity is not present in the model.

Analysis of Hausman Test:

The difference between fixed effect and random effect is called Hausman test. The test will tell us fixed effect is better or random effect is better. If we will reject alternate hypothesis then fixed effect is better and if we will reject null hypothesis fixed effect is better. If the probability value is greater than 0.05% then random effect test is better and if the probability value is less than 0.05% then fixed effect is better than random effect test. There is below hypothesis of Hausman test.

Null Hypothesis(H_0) = Randon effect is better than fixed effect

Alternate Hypothesis(H_1) =Fixed effect is better than random effect

This test tells us if the probability value is greater than 0.05%, we will accept null hypothesis it's mean that random effect is better than fixed effect. If the probability value is less than 0.05% then we will reject the null hypothesis and accept the alternate hypothesis it's mean that fixed effect is better than random effect.

Table 7: The Result of Hausman Test

Correlated Random Effects - Hausman Test			
Equation: Untitled			
Test period random effects			
Test Summary	**Chi-Sq. Statistic**	**Chi-Sq. d.f.**	**Prob.**
Period random	117.5478	7	0.0000

Source: Author's Calculations

The above table 7 shows the results of Hausman test. The results show that the probability value is less than 0.05% so here we will reject the null hypothesis and accept the alternate hypothesis So fixed effect is better than random effect.

Analysis of Redundant Fixed Effects Test:

The difference between common constant method and fixed effect method is called Redundant fixed effects test. Through this test we can decide which test is suitable for our analysis. So, the probability value is greater than 0.05% we will reject the alternate hypothesis and accept the null hypothesis, it means the common constant method is better than the fixed effect method. If the probability value is less than 0.05%, we will reject null hypothesis and accept alternate hypothesis it's mean that fixed effect test is better than common constant test. The hypothesis of Redundant fixed test is as follows

Null Hypothesis (H0) = Common constant effect is better than fixed effect test

Alternate Hypothesis (H1) = Fixed effect test is better than common constant test

Table 8: The Results of Redundant Fixed Effects Test

Redundant Fixed Effects Tests			
Equation: Untitled			
Test cross-section fixed effects			
Effects Test	**Statistic**	**d.f.**	**Prob.**
Cross-section F	32.50124	-7,201	0.000
Cross-section Chi-square	163.5133	7	0.000

Source: Author's Calculations

The table above 8 shows that the probability value is less than 0.05%, So we will reject the null hypothesis and accept the alternate hypothesis. It's mean that the fixed effect test is better than the common constant method.

Results of Fixed Effect Regression Analysis:

The fixed effects model is employed to examine the relationship between economic growth, foreign direct investment, energy consumption, and carbon emissions in South Asian developing countries. Carbon dioxide emissions are used as a proxy for environmental degradation. The primary objective of this model is to test the validity of the Environmental Kuznets Curve (EKC) hypothesis in the selected countries. Table 8 presents the estimated results of the fixed effects regression model.

The results indicate that trade openness has a positive and statistically significant association with carbon emissions, suggesting that increased economic integration may intensify environmental pressure in South Asian developing countries. This finding is consistent with earlier empirical studies that report higher emissions in economies where trade expansion is dominated by energy-intensive and pollution-intensive production processes (Copeland & Taylor, 2004; Shahbaz et al., 2021).

Similarly, foreign direct investment is found to be positively and significantly associated with carbon emissions. This result supports the pollution haven hypothesis, which argues that foreign investors may relocate pollution-intensive activities to countries with relatively weak environmental regulations. Comparable findings have been reported for developing economies by Cole et al. (2017) and Omri et al. (2014), who document that FDI inflows can exacerbate environmental degradation when regulatory enforcement is weak.

Economic growth exhibits a positive coefficient, while the squared term of GDP is negative and statistically significant. This confirms the presence of an inverted U-shaped Environmental Kuznets Curve, indicating that environmental degradation initially increases with economic growth but begins to decline after a certain income threshold is reached. This result is in line with the EKC hypothesis originally proposed by Grossman and Krueger (1995) and supported by subsequent studies for developing countries, including Shahbaz et al. (2013) and Destek and Sarkodie (2019).

Regarding energy consumption, non-renewable energy consumption has a positive and statistically significant effect on carbon emissions, highlighting the role of fossil fuel dependence in environmental degradation. This finding is consistent with previous empirical evidence suggesting that reliance on coal, oil, and natural gas increases carbon emissions in developing economies (Ozturk & Acaravci, 2010; Sadorsky, 2009). In contrast, renewable energy consumption is negatively and significantly associated with carbon emissions, indicating that increased use of renewable energy contributes to improved environmental quality. Similar results have been documented by Bhattacharya et al. (2016) and Pao and Fu (2013), who emphasize the environmental benefits of renewable energy adoption. Overall, the findings underscore the importance of economic structure, energy composition, and investment patterns in shaping environmental outcomes in South Asian developing countries.

Table 9: The Results of Fixed Effects Regression Analysis

Dependent Variable: CO2				
Method: Fixed Effect Method				
Period Included: 33 (1997 – 2022)				
Cross-Section Included: 8				
Total Panel Observations: 216				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TO	0.78513	0.000559	0.121367	0.0028
FDI	0.045188	0.003999	1.130111	0.0248
GDP	0.338245	0.002811	2.933694	0.0038
GDP2	-0.48694	4.537022	-2.11199	0.0360
NREC	0.104053	0.001669	1.457735	0.0491
REC	-0.00234	0.000604	-3.87512	0.0001
C	0.214736	0.068794	3.121421	0.0021
R^2 0.975324			**Adjusted R^2**	**0.944177**
F-Statistic 859.368			**Durbin-Watson Stat**	**2.351306**
Prob(F-statistic)	**0.00000**			

Source: Author's Calculations

The above table 9 also show the value of R^2, adjusted R^2, F-statistics, Durbin Watson and probability(F-statistic). R^2 explain the variation in the dependent variable that is explained by independent variables. The range of R^2 lies between 0 to 1. If the value of R square is close to zero the model is not good fit. If the value is close to 1 the model is good fit for the analysis.

The value in above table shows that 97.53 dependent variable is explained by independent variables included in the model. This shows that the model is good fit. In multiple regression model Adjusted R square explains the limitation of R square. If we will add more variables in the model R square will increase but adjusted R square will explain the addition of unnecessary variables. Adjusted R square is less than R square.

The value of F- statistics is 859.368 and probability value is 0.000 which is positive and significant. The probability value shows that the model is good for analysis. The Durbin Watson test is used to check the problem of auto correlation in the data set. The value of Durbin Watson test lies from 0 to 4. If the value is close to zero there is problem of autocorrelation, if the value is greater than 2 there is no autocorrelation. In above table the value of Durbin Watson test is 2.351306 which shows that there is no autocorrelation.

Discussion of Findings

The empirical findings provide strong support for the Environmental Kuznets Curve hypothesis in South Asian developing countries. The inverted U-shaped relationship between economic growth and carbon emissions suggests that economic development alone does not automatically lead to environmental improvement. Instead, environmental benefits emerge only after countries reach higher income levels and adopt cleaner technologies and effective environmental policies. The positive impact of foreign direct investment on carbon emissions indicates that, in the absence of stringent environmental regulations, FDI may exacerbate environmental degradation. This highlights the need for policy frameworks that attract environmentally sustainable investment rather than pollution-intensive industries. The contrasting effects of renewable and non-renewable energy consumption emphasize the critical role of energy structure in shaping environmental outcomes. Transitioning from fossil fuels to renewable energy sources can significantly reduce carbon emissions and support long-term environmental sustainability.

Conclusion and Policy Implications

This study examines the relationship between economic growth, foreign direct investment, energy consumption, and environmental degradation in South Asian developing countries over the period 1997–2022. Using panel data techniques and a fixed effects estimation approach, carbon dioxide emissions are employed as a proxy for environmental degradation to test the Environmental Kuznets Curve (EKC) hypothesis and identify key determinants of environmental pressure in the region.

The empirical findings reveal that economic growth has a significant impact on environmental degradation. The positive coefficient of GDP and the negative coefficient of GDP squared confirm the existence of an inverted U-shaped Environmental Kuznets Curve in South Asian developing countries. This indicates that environmental degradation increases during the early stages of economic development but begins to decline after a certain level of income is reached. The result suggests that economic growth alone does not guarantee environmental improvement unless it is accompanied by structural changes, technological advancement, and effective environmental policies.

Foreign direct investment is found to exert a positive and statistically significant effect on carbon emissions. This implies that, in the context of South Asia, FDI inflows are associated with increased environmental degradation, supporting the pollution haven hypothesis. The finding highlights the importance of regulatory quality and environmental standards in determining the environmental consequences of foreign investment.

Energy consumption plays a crucial role in shaping environmental outcomes. Non-renewable energy consumption significantly increases carbon emissions, reflecting the heavy dependence of South Asian economies on fossil fuels. In contrast, renewable energy consumption has a negative and significant effect on carbon emissions, indicating its potential to mitigate environmental degradation and support sustainable development.

Trade openness also contributes positively to carbon emissions, suggesting that increased trade activities may intensify pollution when environmental regulations are weak and production processes are energy-intensive. This result underscores the need to integrate environmental considerations into trade and industrial policies.

Policy Implications

The findings of this study provide several important policy implications for South Asian developing countries. First, policymakers should recognize that economic growth and environmental sustainability must be pursued simultaneously. While economic growth is essential for development, it should be guided by policies that promote cleaner production techniques, energy efficiency, and technological innovation to reduce environmental pressure.

Second, governments should strengthen environmental regulations related to foreign direct investment. Environmental impact assessments, stricter compliance standards, and incentives for green investment can help ensure that FDI contributes to sustainable development rather than environmental degradation. Encouraging investment in environmentally friendly industries and renewable energy projects can reduce the negative environmental effects of foreign capital inflows.

Third, a transition from non-renewable to renewable energy sources is critical for reducing carbon emissions. Policymakers should promote renewable energy adoption through subsidies, investment incentives, and supportive regulatory frameworks. Expanding renewable energy infrastructure can improve environmental quality while meeting growing energy demand.

Fourth, trade policies should incorporate environmental standards to minimize pollution associated with increased economic integration. Promoting cleaner technologies, enforcing environmental regulations in export-oriented industries, and encouraging sustainable trade practices can help balance economic growth with environmental protection.

Finally, regional cooperation among South Asian countries can play an important role in addressing environmental challenges. Sharing best practices, technological knowledge, and policy experiences can enhance the region's capacity to achieve sustainable development.

Limitations and Future Research

Despite its contributions, this study has certain limitations. The analysis focuses on carbon dioxide emissions as the sole indicator of environmental degradation, which may not capture other dimensions of environmental quality such as water pollution or biodiversity loss. Future research may incorporate additional environmental indicators to provide a more comprehensive assessment. Moreover, extending the analysis to include institutional quality and technological innovation could offer further insights into the growth–environment nexus in South Asia.

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