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Energy Consumption, Economic Growth and Environmental Quality in South Asian Developing Countries: A Panel Data Analysis

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Abstract

In coming future, developing economies expanding than advance economies. In this study, we attempted to investigate the effects of energy consumption and economic development on the environmental quality in developing south Asian nations. The time period 2000–2020 and used PMG-ARDL. According to the research, economic expansion and energy use have favorable effects on the environment. Further, the findings show that all variables in Asian nations indicate cross-sectional dependence (CSD). The results of the study suggest that practical implications must be employed in order to attract people towards the use of renewable energies. According to the long-run results, NONRNW, GDP, and FDI cause harm to the environment by increasing CO2. On the other hand, RNW decreases CO2, but it is insignificant while other variables are significant. The outcomes of the CD methods explain the presence of CSD, and the Pedroni Panel Cointegration Test results reveal long-run cointegration among variables. Practical implications must be employed in order to attract the masses to use renewable energy sources more. Subsidies and incentives must be given to people for using renewable energy, and it should be made cheaply available.

Keywords: CO2, environmental quality, Panel-ARDL, South Asia

Introduction

The economies of developing countries are rapidly expanding, and this will continue in the future. The agricultural land is being reduced as the industrial sector expands. And also, growing masses is source of deforestation. The rising population is creating food demand which is associated agri-sector and energy is necessary for agricultural sector. This affects the environment and causes environmental degradation. Environmental degradation has worse consequences for humans' health. Carbon dioxide emissions are produced by toxic materials released from factories and the use of wood. *A negative effect of carbon dioxide is seen in the economy and other areas. Numerous studies have examined the primary causes of environmental degradation, which are energy use and economic growth.* Developing economies like Bangladesh, Sri Lanka, India and Pakistan, are facing the problem of environmental degradation, which, as a result of the accelerated economic expansion, has a detrimental effect on the economy (Azam and Khan, 2016). We are aware that the environment has a significant impact on economic growth. Natural resources are required to support today's economic growth and development. Several challenges come up when we talk about the relationship between economic growth and environmental quality. But this fact cannot be ignored: energy is the lifeblood of an economy. The reason is that without heat, light, and power, firms, industries, and transport cannot run. Goods cannot be produced. This demonstrates how much energy is required for economic well-being. Aside from that, energy consumption has a negative impact on the environment. Energy comes from oil, coal, and natural gas, which have harmful impacts on the environment by producing CO2, SO2, methane, and other poisonous gases (Munsif et al., 2021). The consumption of petroleum is the main cause of environmental pollution. The demand for petroleum consumption is increasing day by day as economic growth increases. Global warming is becoming more severe as energy consumption rises, making sustainable development more difficult. We know that economic growth and development are not possible without the use of energy. Energy is one of the significant important

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elements for any type of production activity. The increasing breadth of the industrial sector has resulted in a substantial rise in demand of energy and consumption. A worsening growth in the use of fossil-fuels can be seen, and it has a terrible impact on the expanding CO2 emissions. So, it is essential to regulator the consumption of fossil fuels to diminish CO2 emissions. This study focuses on developing economies in Asia, including those in Pakistan, Bangladesh, Nepal, Sri Lanka, and other countries. This study examines how economic development and renewable and non-renewable energy sources affect environmental quality. It is a severe issue that the temperature of the earth is increasing day by day; this is due to higher energy consumption, which is a cause of climatic change. This is because of energy consumption for the sake of economic development. (Ansari et al., 2020) examined how important energy is to a nation's economic development. Energy is needed for both production and consumption. Energy use greatly contributes to economic expansion. According to Khan et al. (2020), non-renewable energy sources are more harmful to the environment than renewable energy sources.

Variables and their impact on Economic growth and CO2 emission:

The link environmental quality and economic growth is complex. Income and CO2 emissions are directly correlated, as shown by the environmental Kuznets curve. Numerous studies have examined the emission of numerous pollutants, including SO2 and CO2 (Zhang et al., 2022; Solarin and Tiwari, 2020; Liu et al., 2018; Schreifels and Wilson, 2012; Cole and Neumayer, 2004;). This paper indicates that major Asian and American countries are considered and smaller emerging economies are ignored. In the present world, the development of urban areas is considered the fastest-trending society, as we see that many rural people come to urban areas for basic economic needs and facilities. This rural-urban migration increases productivity, which consumes more energy and hence causes environmental degradation and poverty. In excess of hemi-world's population is estimated to live in cities, and this figure is expected to rise further in the future (Cheland, 2013; Ritchie and Roser, 2018). So, urbanisation is an important factor in environmental degradation. It also increases the volume of trade all over the world (Liang et al., 2019).

Trade has a significant impact on the environment. Higher energy consumption is linked to trade activities, particularly when items are manufactured and transported. The environmental-trade relationship has produced mixed results (Ibrahiem and Hanafy; 2021). Some researchers, using different parameters, explored the positive impact. Some have discovered that while trade initially harms the environment, it eventually improves it by implementing clean technologies. It is necessary to adopt effective clean technologies for sustainable growth. This study considered the role of trade openness (Wiedmann et al., 2007; Yao et al., 2020).

The environment is impacted differently by various energy sources. Each type and pattern of energy consumption associated with an energy source can be distinct from other patterns. This study has focused on different types of energy pattern and selected five sources of energy that are mainly used in Asian developing countries like Sri Lanka, India, Nepal, Bangladesh, and Pakistan. Oil, coal, and natural gas are the three main energy-producing sources. The study investigated how FDI affected environmental quality and economic growth. FDI necessary for development of these economies. In developing economies special Nepal, Bangladesh, India, Sri Lanka and Pakistan, FDI is an important factor that helps in transferring new technologies and boosts the employment of the host countries (Gul and Khan, 2021).

However, it has been discovered that FDI, which promotes economic expansion, has a negative effect on environmental quality. Therefore, non-renewable energy sources that contribute to carbon dioxide emissions are necessary for economic growth. Many researchers have shown that FDI has a positive impact, but some have argued that it has a negative impact. The entrance of FDI into developing countries brings environmental pollution that harms their environment. Environmental FDI has an important effect on environmental pollution in developing economies (Yang and Li 2019; Yu and Li, 2020).

Hypotheses to be teste:

H1: Does renewable energy have an effect on CO2 emissions? Is the relationship between these two positives or negative?

H2: Does nonrenewable energy interact with CO2? Is the relationship between nonrenewable energy and humans positive or negative?

H3: Does the FDI collide with environmental quality or not? Is the relationship between these two positives or negative?

Literature Review

Despite the circumstance that economic growth is the backbone of the country's economy, it also has a severe influence on the environment. Energy is needed for the growing process, and the usage of that energy contributes to air pollution. Previous studies have shown a correlation between economic growth and energy consumption. It can sometimes be better for environmental quality and sometimes be worse.

Oktavilia et al. (2019) examined that the association economic growth and energy consumption and impact on environmental quality. Data nature is cross-sectional and sample 34 provinces of Indonesia. The study analyzed three approaches: the random effect approach, the common effect approach, and the fixed effect approach. The outcomes shown that economic growth is positively linked to environmental quality. The study concluded that there is a trade-off between developing and poor countries. Additionally, in various places technology not an environmental friend. The study showed that the nation has made progress and is conscious of how the environment is improving.

Nawaz et al. (2020) examined the outcome of energy expenditure in developing countries. The usage of nonrenewable energy is the root of environmental deterioration, according to the report. They influence the expansion of the world economy. In emerging economies like Pakistan, the study looked at the relationship between energy use, economic expansion, and CO2 emissions. The ARDL method for investigating co-integration among variables. The study recommended that the government of Pakistan improve energy resources that will assist satisfy the rising energy needs by replacing outdated energy sources like coal.

Ungwanitban et al. (2020) investigated the effects on the environment of FDI, non-renewable and renewable energy sources, and economic expansion of Thailand. The time series data from 1990 to 2018 were utilized in this study. The study used the technique of the ARDL for co-integration in the model. This study examined the damaging effects of expansion on the ecosystem, supporting the EKC's existence. They also found that, FDI and renewable energy sources are negatively connected to CO2 emissions. According to this study, FDI and renewable energy have a positive effect on lowering CO2 emissions.

Anser et al. (2021) investigated the impact of renewable and non-renewable energy consumption and CO2 emissions on Pakistan's growth. The study took the data from 1990 to 2017. The study applied the ARDL. Non-renewable energy resources are oil consumption, coal consumption, and natural gas consumption. GDP, labor, and capital are dependent variables. The result of the study explored the fact that renewable energy resources and CO2 emissions are positively related. Non-renewable energy is negatively related to the economic growth of Pakistan. A study suggested that Pakistan should control its use of non-renewable energy resources. The Pakistani government and private firms try to finance renewable energy projects.

Ho and Ho (2021) analyzed the existence of a of economic growth and energy along with environmental quality in Vietnam by balancing ages from 1995 to 2018. The study applied the ARDL. The study explored the long-run equilibrium association between CO2, income, energy consumption, trade-openness, and FDI. The study investigated a positive association between income and CO2 emissions. The research paper presented the elasticity of the long-run connection between carbon dioxide and income as being minor. The study also found that energy consumption is positively connected with carbon dioxide emissions and FDI is negatively linked, while trade openness has a positive impact. As a result, the study concluded that clean technologies that reduce the use of carbon-intensive technologies should be developed.

Xie et al. (2021) explored how the use of renewable energy and economic growth are connected to air pollution. A dynamic panel technique was employed in the investigation. Major air contaminants including carbon monoxide, nitrogen oxide, and Sulphur dioxide (SO2) were employed in the study. In this work, the environmental Kuznets curve was also examined. Data from 145 nations was gathered for the years 2000 to 2014. According to the findings, using renewable energy lowers air pollution. According to the findings, trade openness decreased carbon monoxide emissions while increasing S02, while urbanization reduced nitrogen oxide and SO2 emissions. According to the study's conclusions, air pollution may be decreased if businesses adopt cutting-edge, environmentally friendly technologies and nations turn to renewable energy sources.

Data and Methodology

We collect the data of some selected developing countries for the purpose of detecting the impact of energy consumption and economic growth on environmental quality. An accurate and consistent source of data is necessary for collection. The suitable variables are adopted, which are mandatory to identify the impact of economic growth and energy consumption on CO2. The environmental quality or deterioration is dependent on dependent variables, which are proxies for this variable: CO2 emission, greenhouse gas emission, nitrogen gas emission, etc. Environmental quality is defined as the harmful and damaged condition of the environment due to the deficiency of natural resources. The absence of natural resources like clean air, water, and grasslands is terribly affecting the environment. For testing the environmental deterioration, CO2 emissions were used as a proxy. The independent variables include non-renewable energy use, renewable energy use, foreign direct investment, and gross domestic product. The data on coal consumption is collected for use as a non-renewable energy use variable. For the variable of renewable energy use, data on renewable energy consumption is collected. Data on GDP in current US dollars is collected for the gross domestic product variable, and data on FDI net inflows is collected for foreign direct investment. The data for CO2, coal consumption, and renewable energy consumption is collected from the Energy Information Administration (EIA). And the data for GDP and FDI are collected from the World Development Indicators database (WDI). The data was collected from 2001 to 2020, and the following countries are included: India, Bangladesh, Sri Lanka, Nepal and Pakistan.

Table 4.1 Data Sources

Variables	Proxies (if used) and Unit of Measurement	Abbreviation	Source of Data
Dependent variable			
Environmental Degradation	CO2 Emissions (MM tones CO2)	CO2	EIA
Independent Variables			
Non-Renewable Energy Consumption	Coal Consumption (Quad Btu)	NONRNW	EIA
Renewable Energy Consumption	Consumption Renewable (Quad Btu)	RNW	EIA
Foreign direct Investment	FDI, net inflows (BOP, current US$)	FDI	WDI
Gross domestic product	GDP (Current in US$)	FDI	WDI

Table 4.2 Expected results and explanatory variables list:

Explanatory Variables	Expected relation	Expected results from previous reviews
Economic growth (GDP)	+	Khan et al. (2021) found that there is a positive link etween GDP and CO_2
Renewable energy	_	Hanif (2018) found that negative link exists between RNW and CO_2
Non-renewable energy	+	Hnif et al (2019) found that positive link exists between NRNW and CO_2
Foreign direct investment (FDI)	+	Khan et al (2021) found that there is a positive relationship between FDI and CO_2

Model Specification:

Fundamental goal of this study is to investigate the association between energy consumption, environmental quality and economic growth in some Asian developing economies. In this study, we focused on the causal association among the particular variables. For this reason, the research pressures on the variable, i.e., an increase in GDP growth will harm the environment, or increased use of NRNW will cause environmental quality to decrease and increased use of RNW will improve environmental quality.

Carbon dioxide= f (GDP, RNW, NRNW, FDI) … (1)

In this model, carbon dioxide is used as the dependent variable, and renewable, non-renewable, GDP, and FDI are used as independent variables. This equation shows that carbon dioxide, which is a proxy for environmental quality, is a function of GDP, RNW, NRNW, and FDI.

Here, we establish a linear equation model which set up the relationship among the variables.

log (Co_2) =f [log (GDP), log (RNW), log (NRNW), log (FDI)] … (2)

After this, we can establish the model for long-run association between the variables that is given as:

Log (CO_2) = α_0 +α_1 log GDP_i □+ α_2 log RNW_i □+ α_3 log $NRNW_i$ □+ α_4 log FDI_i □+ ε_i … (3)

Here, i, t and ε are represent countries, time periods and error term.

Log CO_2 = log of environmental quality or deterioration

Log GDP = log of economic growth

Log RNW= log of renewable energy

Log NRNW= log of non-renewable energy

Log of FDI= log of Foreign Direct investment

In this analysis, we applied the Panel ARDL technique to explore the long-run relationship between energy consumption, economic growth, and environmental quality. The above equation shows the dependent variable as carbon dioxide from Asian developing countries selected for analysis. And independent variables such as GDP, non-renewable energy, renewable energy, and FDI are used. The α_0 is the intercept, and α_1 , α_2 , α_3 , α_4 are the intercepts of long run analysis.

Methodology

Panel ARDL techniques of co-integration are applied to examine the above model. This model contains carbon dioxide as a dependent variable and GDP, FDI, RNW, and NRNW as independent variables.

Advantages of panel data:

Panel data (cross-sectional data), in which the behaviour of objects is experiential crosswise time. The combination of cross-sectional (CS) and time-series data is also known as panel data. It is also beneficial because it is valuable for analyzing many cross-section parts, like countries. Following are some advantages of panel data:

1. It provides the most practical consequences because of the large size of the sample.
2. The contrast between time series data and panel data does not give a biased judgement. This is because parameters are simple in panel data.
3. It is easier to accrue the effort of an individual's reply compared to cross-sectional and panel data.
4. It provides the most appropriate results for the variables used in the model because it is often based on degrees of freedom and has hardly any multicollinearity as compared to time series data and cross-sectional data.

Methodologies;

The above model relies on linear panel data. For checking the stationarity of the data, the panel unit root test is applied. The stationarity test results in two degrees of stationarity. Few parameters in this stationarity test are stationary at the first difference, and even fewer are stationary at level. This discloses the unit fusion level. The panel unit root test result validates the use of the ARDL co-integration technique.

Stationarity:

If the co-variance is persistent with a persistent mean and variance, it means time series are appearing as stationary. If the data is accepted as non-stationary data, then this assumption is not fulfilled.

Panel-unit-root-test:

For checking the stationarity of panel-data, a panel-unit-root-test is applied to the model. From two types of data, we can check the stationarity of panel data, such as:

1. Im, Pesaran, and Shin test (IPS)
2. Levin-Lin and Chu test (LL&C)

The Im, Pesaran and Shin test (IPS)

This type of test is introducing by three economists, Kyung So Im, M Hashem Pesaran& Young Cheol Shin in 2003, and known as Im, Pesaran & Shin test. This test tells us that coefficients of variables are heterogeneous. This IPS test authorizes the several parametric points and analysis for ith part. In the model we talk about two points which are as:

1. If all the data is non stationer, then it is known as null hypothesis.
2. If all the data is stationer, then it is known as alternate hypothesis

Im, Pesaran & Shin allows the prediction by which t-test is beneficial for balanced panel data. “t” has to be similar for many cross-sectional components. Lagrange Multiplier (LM) test is useful in the long run.

The Levin-Lin & Chu test (LL&C)

This is the first type of panel-unit-root-test, known as the Levin-Lin & Chu test, which was presented by two economists, Andrew Levin and Chien-Fu Lin, in 1992. This test was eventually known as "Levin-Lin and Chu" in 2002 with the help of Chia-Shang James Chu. This panel unit root test is an enlargement of the Dicky-Fuller (DF) unit root test. There are two steps to checking the stationarity of data. The first step is a unit-specific fixed effect, and the second step is a unit-specific time trend. The first step refers to authorizing the divergence and the lag coefficient of dependent variable analogues in several units. That’s why this method is a very useful procedure. A mostly cross-sectional model is regarded as independent through the LL & C test.

Bound test procedure;

Before applying the ARDL technique bound test is applied this is the part component of ARDL technique. Bound test is helpful to perceive the long run relation between the independent variables. These Assumptions of this procedure such as.

1. If the value of bond test is smaller, then among the independent variables there is no long run relation.
2. Greater value of the bond test means long run relation is existing among independent variables.
3. This system permits neutral and systematic outcomes.

Equation in the form of VECM known as vector error correction model. The equation includes both Dependent and independent variable, time period with lad values

The equation in the form of vector error correction model can be written as:

$\Delta\log(CO_{2\,i\,\square})=\alpha_0+\alpha_1\log(GDP_{i\,\square-1})+\alpha_2\log(RNW_{i\,\square-1})+\alpha_3\log(NRNW_{i\,\square-1})+\alpha_4\log(FDI_{i\,\square-1})+\sum k_i=1\square_1\,\Delta\log(GDP_{i\,\square-1})b+\sum k_i=0\square_2\,\Delta\log(RNW_{i\,\square-1})+\sum k_1=0\square_3\,\Delta\log(NRNW_{i\,\square-1})+\sum k_i=1\square_4\,\Delta\log(FDI_{i\,\square-1})+\mu_{i\,\square}$ … (4)

The above equation shows the relationship between independent and dependent variable in both long and short run;

α_0 = intercept

α_1 , α_2 , α_3 , α_4 = coefficients of long run

$\sum$ and Δ = shows the dynamics of short run

$\square_1$ $\square_2$ $\square_3$ $\square_4$ = coefficients of long run

μ = error term

This equation estimates the impact of energy consumption, GDP, and FDI on CO2.

Model estimation Criteria;

The model's selected variables exhibit stationarity at level 0. At this level of research, the variables are analyzed using the fixed effect model or the random effect model. If the variables of the research analysis show stationarity at the first difference (1), the variables chosen for this study are analyzed using the generalized method of movement (GMM). Because of different stationarity levels, the technique of Panel ARDL is applied, which gives both long- and short-term relations between CO2, energy consumption, and GDP.

A panel auto regressive distributive lag model;

This technique is suitable for a simple equational model. For the analysis of the variables in both the short and long run, it is considered a useful technique. Even for small panel data, the P-ARDL model provides successful and practical results. For the implication of the P-ARDL technique, the panel unit root test is the basic point. In this research analysis, series are stationary at different levels, such as 1(0) and 1(1). Because of these combined degrees of stationarity, the P-ADRL is applied for the analysis of the variables. It is initially used for long-run variable association, but it is later used for long-run and short-run variable linking.

Long run and short run estimates of panel data:

Panel data is applied to analyze the short- and long-term estimations of carbon dioxide, GDP, RNW, NRNW, and FDI. In the short run, research has identified some variables that may be significant and some that may be insignificant, which shows that these variables do not influence the environmental quality of the economy. In the long run, all series are significant and influence environmental quality.

Cross-sectional Dependence test

CD test is very helpful in panel data analysis. Pesaran (2006) has focused on the significance of cross-sectional dependence test for panel data research and identified that ignoring this feature can be the reason of fundamental deviations and size warp. This study carries out cross-sectional dependence test on our panel model. Following is the equation of cross-sectional dependence test:

$$y_{i} \square = \alpha_{i} = \square ixit + \varepsilon_{i} \square \text{ for } i-1\ldots N \text{ and } t=1\ldots T \ldots (5)$$

In this equation,

yit and xit = dependent and independent variables

i and t = cross section and time periods

ai and bi = shows the individual intercept and slop respectively;

ε_i □ = independently distributed error term.

There is no dependency between any two cross sections if,

For any i ≠j, cov(ɛ it, ɛ jt) = 0

There is a dependency if,

Cov(ɛ it, ɛ jt) ≠ 0

H_0 = dependency exist among any two cross sections

H_1 = no dependency exists among any two cross sections

For testing the above hypothesis, we can apply the LM test, also known as the Lagrange multiplier test, which was presented by Breusch and Pagan in 1980. Although the LM test is only applicable for those panels whose T is large and N is relatively small, to overcome this limitation, Pesaran in 2004 presented the CDLM test, which stands for the LM test for cross-sectional dependence. For adjusting the bias of the LM test and solving the drawback of the cross-sectional test, Pesaran and Yamagata (2008) presented the LM-adj test (bias-adjusted LM test).

The Panel Co-integration test:

This test is used in the analysis to test the long-run relationship between the model's variables. This test can be used to examine both short-term and long-term relationships between variables. Pedroni (1999, 2004) developed a test analysis known as the Engle and Granger co-integration model (1987), which accounts for significant heterogeneity. The co-integration test equation will be as follows:

$$\varepsilon_{i} \square = wi\, \varepsilon_{i} \square_{+ u} \text{ it} \ldots (7)$$

Pedroni, from 1999 to 2004, presented seven tests of co-integration, in which there are three groups of mean panel co-integration tests. The methodology is based on the division of the numerator by the denominator prior to adding the N-dimensions. The other tests of co-integration consist of within-dimension tests, and their methodology is as easy as adding both the numerator and denominator separately above the N-dimensions.

The study of the panel co-integration test presented by Pedroni in 1999 goes on to examine whether the variables in the model are associated in the long run based on the results of the variables' stationarity and unit root tests. Panel co-integration has a variety of characteristics, and with the various individual outcomes, it allows for cross-sectional interdependence. There are the seven tests of co-integration established by Pedroni, and these tests are divided into two groups, such as:

1. The panel-v statistic
2. The panel rho-statistic

The other tests such as, the panel ADP test, the panel PP-test is inside the dimension, and the remaining three tests are outside the dimensions. Regression is based on the pooling within the dimension, and outside the dimension regression is constructed on averaging.

Lag selection:

There are two types of lag selection:

1. Fixed lag selection
2. Automatic lag selection

The same lag length is chosen for independent and dependent variables in fixed lag selection, whereas it is chosen automatically in automatic lag selection, but the first maximum lag is chosen for both dependent and independent variables in automatic lag selection. Different lag selections can be set out for both dependent and independent variables in automatic lag selection. In this research, automatic lag selection is employed.

Error Correction Mechanism:

An error correction model is used to inspect the coefficients of the long and short runs. For adjustment purposes, this mechanism is adopted. The main purpose of an error correction model is to inspect the existence of short-run links between variables and to secure the presence of long-run associations. Some advantages of VECM include the following:

1. ECM is applied to detach the trend inequality in variables, which is put on by adding their lagged terms in the model, and to remove the issue of spurious estimation.
2. From general form to particular form, it can simply fit in the model; that's why it is known as the "best fitted model.
3. It balanced the long-run association and was implied as a tool of adaptation in the dynamic ECM model.

Long run and short run relationships:

The pointedly objective of this research is to observed the short and long-term impacts of energy consumption and economic growth on CO2 emissions in Asian developing economies. The above equation shows the short- and long-run coefficients of an independent and dependent variable. The bound test process is used to analyze the existence of a long-term connection for this purpose. The long-term impact of energy consumption and economic growth on environmental quality is depicted in the panel auto-regressive distributed lag model coefficient equation below.

$\Delta\log(CO_{2\,i}) = \alpha_0 + \alpha_1\,\Delta\log(GDP_{i\,\square\,\square 1}) + \alpha_2\,\Delta\log(RNW_{i\,\square\,\square 1}) + \alpha_3\,\Delta\log(NRNW_{i\,\square\,\square 1}) + \alpha_4\,\Delta\log(FDI_{i\,\square\,\square 1}) + \mu_i$ … (7)

After observing long run association between dependent and independent variables, we observe the short run association which is as follows.

$\Delta\,Log(CO_{2\,i\,\square}) = \square_0 + \Sigma k_i = 0\square_1\,\Delta\log(GDP_{i\,\square\,\square 1}) + \Sigma k_i = 0\,\square_2\,\Delta\log(RNW_{i\,\square\,\square 1}) + \Sigma k_i = 1\square_3\,\Delta\log(NRNW_{i\,\square\,\square 1}) + \Sigma k_i = 0\square_4\,\Delta\log(FDI_{i\,\square\,\square 1}) + \mu_i$ … (8)

Above equation shows that highly significant error terms express the powerful presence of strong association between dependent and independent variables.

Panel causality test:

This test was presented by Dumitrescu and Hurlin (2012) developed a statistic to examine the causality in panel data. This test is the expanded form of Granger causality test. The regression equation written as follows:

$$Y_{i\,,\square} = \alpha_0 + \Sigma^{K}{}_{\square = 1} + \gamma_{i\,\square}\, x_{i\,,\square - \square} + \varepsilon_{i\,,\square}$$

In above equation,

$x_{i\,,\square}$ and $y_{i\,,\square}$ = observations of two stationarity variables i individual in time period t

Coefficients are allowed to vary over the individuals but are suppose time invariant. K is represented as lag order which suppose as similar for all individual and because of this panel required to balance. Granger in 1969, established the procedure to analyze the causality, the null hypothesis can be written as

$$H_o : \gamma_{i\,1} = \gamma_{i\,\square} = 0\ \square\ i = 1\ldots N_1$$
$$H_1 : \gamma_{i\,1} = \gamma_{i\,\square} = 0\ \square\ i = 1\ldots N_1$$
$$\gamma_{i\,1}\ 6 = 0 \text{ or } \ldots \text{ or } \gamma_{i\,\square}\ 6 = 0\ \square\ i = N_1 + 1, \ldots N$$

This hypothesis shows the absence of causality for all individuals in the panel. The test shows that there is causality for some individuals in the data, but not for all of them. If N1 = 0, then there is a causal relationship for all individuals. N1 is rigidly smaller than N; apart from that, there is no causality for all individuals. And H1 will be renamed Ho. We use carbon dioxide as a dependent variable and GDP, non-renewable energy consumption, and FDI as independent variables. Some Asian developing countries from the South Asian region are chosen. The P-ARDL method is then used to check the data's degrees of stationarity. This technique is also adopted for checking the long and long run associations. The cross-sectional dependence test, panel con-integration test, and error correction model are also explained in this chapter. Finally, the panel causality test is examined.

Data Analysis, Results and Estimation

Table 5.1 Descriptive Analysis

	CO2	**NONRNW**	**RNW**	**GDP**	**FDI**
Mean	374.4573	2.350986	0.419323	406.1025	6.711867
Median	58.70586	0.054238	0.045910	91.69591	1.036960
Maximum	2314.738	16.35015	2.865937	2870.504	64.36236
Minimum	2.414287	1.143406	0.004597	6.007055	-0.006648

Std. Dev.	675.6116	4.864432	0.705656	704.2103	13.72955
Skewness	1.833991	1.891924	1.935168	2.208371	2.357553
Kurtosis	4.845643	5.033964	5.657131	6.714548	7.508462

The above table shows the statistical results for CO2, NONRNW, RNW, GDP, and FDI. The CO2 value of mean is 374.4573, and minimum is 2.414287, and its maximum value is 2314.738. The median for CO2 is 58.70586. The standard deviation of CO2 is 675.6116. Therefore, the values 1.833991 and 4.845643 are the values of skewness and kurtosis, respectively. The mean of NONRNW is 2.350986 and maximum and minimum values are 16.35015 and 1.143406 respectively. The results show that the values of standard deviation, skewness, and kurtosis are 4.864432, 1.891924, and 5.033964, respectively. The RNW mean value, which is displayed in the table above, is 0.419323. The smallest and largest values are 0.004597 and 2.865937, respectively. The results depict that 406.1025 is the mean value of GDP. The maximum value and minimum value are 2870.504 and 6.007055, respectively. The mean value lies in between the maximum and minimum values. The value of the standard deviation is 704.2103. The value of skewness is 2.208371. The value of kurtosis is 6.714548. The mean value of FDI according to the results in the above table is 6.711867. The minimum value is -0.006648, and the maximum value is 64.36236. The minimum value is < mean value, and the maximum value > mean. The standard deviation is 13.72955. The skewness value is 2.357553 and the kurtosis value is 7.508462.

Table 5.2 Correlation Matrix

	CO2	**NONRNW**	**RNW**	**GDP**	**FDI**
CO2	1				
NONRNW	0.835143	1			
RNW	0.807170	0.727437	1		
GDP	0.973812	0.859064	0.781760	1	
FDI	0.720776	0.643669	0.724601	0.749886	1

Table 5.2 shows the correlation matrix, which shows how much the variables are correlated to each other. Through the correlation matrix problem, the degree of multicollinearity among the variables is specified. On the diagonals, the value is 1 because it shows the correlation of a variable with itself. Therefore, the independent variable NONRNW is strongly positively correlated with the regressand variable CO2. The exogenous variable RNW is shown to be positively and strongly correlated to the predictand variable CO2. The predictor variable, GDP, is strongly and positively correlated with the explained variable, CO2. The response variable CO2 and the stimulus variable FDI have a substantial and positive correlation. It can also be seen that RNW and non-RNW have a strong and positive correlation. The Strong and positive correlations exist between GDP and RNW and NONRNW, as well as between the two variables. As can be shown, GDP, NONRNW, and RNW have a positive and robust relationship with FDI. The RNW, GDP, and FDI all have substantial positive correlations with the NONRNW.

Cross sectional dependence tests:

H_0 = No dependency any two cross sections

H_1 = Dependency any two cross sections

To check the above hypothesis, we can apply the LM (Lagrange multiplier) test, which was presented by Breusch and Pagan in 1980. as the LM is only applicable for panels whose N-small and T-large. Pasaran in 2004 presented the CDLM, which stands for the LM test of cross-sectional dependence and a better CD statistic to control this limitation. Pasaran and Yamagata (2008) also presented the LMadj (bias-adjustment LM test) statistic to manage the bias of the LM statistic and control the drawback of the CD test. We may compare these four findings to decide whether to accept or reject the null hypothesis that there is no cross-sectional dependency.

Table 5.3 CD Test results:

TEST	**CO2**	**NONRNW**	**RNW**	**GDP**	**FDI**
Breusch-Pagan LM	178.8517***	141.5132***	104.1929***	189.2662***	67.09935***
Pesaran scaled LM	36.63836***	28.28922***	19.94414***	38.96710***	11.64977***
Bias-Corrected scale LM	36.50678***	28.15764***	19.81256***	38.83552***	11.51819***
Pesaran CD	13.36786***	11.82779***	9.976566***	13.75506***	6.966358***

Table 5.3, if the cross sections are dependent on each other or not. The level of significance in the above table is shown by the "*" symbol. One * indicates that the variable is significant at 10%, two ** indicates that it is significant at 5%, and three *** indicate that it is significant at 1%. The

results of the above table have three *** on each value. According to all four tests, CO2, NONRNW, RNW, GDP, and FDI are all significant at the 1% level of significance. The results prove that because all the variables are significant, the cross-sectional dependence exists in this variable. Thus, all these cross sections are interlinked with each other, affect each other, and are dependent on each other. Changes and effects in one cross section will spread to other cross sections due to the existence of CSD.

Panel data analysis:

The ARDL approach is used to evaluate how energy use affects economic development and environmental quality in emerging nations in Asia. Managing the integration of the data is necessary for the implications of the ARDL model. Therefore, for stationarity level, the panel unit root test is applicable.

Table 5.4 Unit Root/Stationarity Test:

Variables		At Level		At 1st Difference		outcomes
		II	II & T**	II*	II & T**	
Log-CO2	LL & C	-2.55 (0.005)	1.24(0.892)	-1.535 (0.062)	-	I (1)
	IPS	1.11 (0.867)	0.85 (0.804)	-3.185 (0.000)	-	
Log-NONRNW	LL & C	-1.79 (0.036)	1.67 (0.952)	-3.108 (0.000)	-	I (1)
	IPS	1.56 (0.941)	1.81 (0.965)	-3.538 (0.000)	-	
Log-RNW	LL & C	-1.79 (0.036)	-1.11 (0.131)	-4.098 (0.000)	-	I (1)
	IPS	0.17 (0.569)	-1.67 (0.047)	-5.356 (0.000)	-	
Log-GDP	LL & C	-2.88 (0.002)	2.42 (0.992)	-1.187 (0.117)	-4.25 (0.00)	I (1)
	IPS	-1.12 (0.131)	3.54 (0.999)	-1.334 (0.091)	-2.45(0.00)	
Log-FDI	LL & C	-5.78 (0.000)	-	-	-	I (0)
	IPS	-4.20 (0.000)	-	-	-	

II* II& T** represent individual intercept and intercept and trend respectively.

In table 5.4, the probability values of the LL&C and IPS tests are 0.0623 and 0.0007, respectively. The independent variable, NONRNW, is stationary at the first difference with an individual intercept. The values of probability for the LL&C and IPS tests are 0.0009 and 0.0002, respectively. The independent variable of RNW is also stationary at the first difference, with an individual intercept and probability values of 0.0000 and 0.0000 for the LL&C and IPS tests, respectively. The findings show that the independent variable GDP is stationary at the first difference, with a single intercept and trend. The probability values are 0.0000 and 0.0071 for the LL&C and IPS tests, respectively. The table shows that the independent variable FDI is stationary at the same level as the individual intercept. The probability of both the LL&C and IPS tests is 0.0000. Thus, according to the stationarity results, CO2, NONRNW, RNW, and GDP are stationary at the I (1) and FDI is I (0). When the level of integration is a mixture of I(0) & I(1) then ARDL technique is applied. If all variables are integrated at level, then OLS is applied. So, the results here show that P-ARDL is applicable to the model of this study.

5.5 Pedroni test for panel co-integration

Through Pedroni find the long run association in projected variables.

Table 5.5 Panel Co-integration Test of Dependent and independent variable:

Test Type: Pedroni Cointegration Test		
Test	**II and IT**	**No Intercept or Trend**
P-v-S	1.424919* (0.0771)	-1.823364 (0.9659)
P-rho-S	-0.757475 (0.2244)	0.855722 (0.8039)
P-PP-S	-7.520177*** (0.0000)	-0.031874 (0.4873)
P-ADF-S	-7.432892*** (0.0000)	-3.093907*** (0.0010)
G-rho-S	2.668062 (0.9962)	1.998801 (0.9772)
G-PP-S	-4.136260*** (0.0000)	-2.357255*** (0.0092)
G-ADF-S	-4.017749*** (0.0000)	-1.394833* (0.0815)

In this table, P, G and S indicate panel, group and statistic. Therefore, II and IT shows individual intercept and trend respectively.

Table 5.5 represents the outcome of the Pedroni cointegration test. Here, the first column of the table above lists the names of seven different tests, which are all part of the Pedroni cointegration test. The tests are calculated with and without individual intercepts and trends, one by one, as shown by the second and third columns. The asterisks (*) indicate the level of importance. Three *** are shown if the results are significant at the 1% level of significance. Two ** are shown if the findings meet the 5% significance threshold for significance. An asterisk (*) is used to denote results that are significant at the 10% level of significance. The Pedroni test results are displayed above in the second column along with individual intercepts and trends. Four of the seven tests have a 1% level of significance with three ***, while one has a 10% level of significance with one *. The Pedroni test results are displayed in the third column of the table without an intercept or trend. One test is significant at the 10% significance level with one, and two tests are significant at the 1% significance level with three *** out of the seven.

Long Run Results:

Therefore, to investigate, how economics and energy use affect environmental quality in developing economies uses the P-ARDL technique. This technique creates a strong connection over time between the regressand and regressor variables. The long-run outcomes shows in the below table.

Table 5.6 Long Run results by using Panel ARDL technique:

Long Run Equation				
Series	**Coefficients**	**Std. Error**	**t-Statistic**	**Prob.**
Log NONRNW	0.058243	0.028248	2.061829	0.0434
Log RNW	-0.002467	0.017628	-0.139936	0.8892
Log GDP	0.400715	0.026977	14.85412	0.0000
Log FDI	0.052916	0.010038	5.271609	0.0000

Table 5.6 shown the outcomes of the long-run of P-ARDL. There is a direct link between the regressor variable NONRNW and the regressand variable CO2. The coefficient-value is 0.058243, which has a positive sign. This means that increases in NONRNW lead to increases in CO2 as well. The probability value of NONRNW is 0.0434 which is significant. When NONRNW increases by 1%, CO2 increases by 0.058243%. various studies have found, non-renewable energy has indirect impact on environmental quality. Hanif et al. (2019) and Ito (2017), have also found that the more use of non-renewable energy causes of the increasing CO2-emissions, that the reasons, degrading the environmental quality. The table depicts that the independent variable RNW is indirectly linked to CO2. The coefficient value is -0.002467, which has a negative sign, implying that increases in RNW cause CO2 to fall or decrease. When RNW increases by 1%, CO2 decreases. According to Hanif (2018), using renewable energy more frequently improves air quality by lowering carbon emissions. The probability value of 0.8892 shows that the impact of RNW is insignificant. This is because the results are for developing countries, where limited fund to access the renewable energy in the first place, and they also do not have concrete policies regarding the use of renewable energy. Parallel results were originated by Hasnisah et al. (2019) for same countries. The results show that the regressor series GDP is positively linked to the regressand series CO2. This means that increases in GDP raise CO2 emissions. The value of the coefficient is 0.400715, which shows that CO2 increases by 0.400715% with every 1% increase in GDP. The probability of GDP is 0.0000, which shows its effect is significant. Khan et al. (2021) found that raised GDP cause CO2 emissions to increase as well, thus causing environmental degradation. Its coefficient value is 0.052916. The positive sign indicates a direct association between the series of FDI and CO2. This depicts CO2 emissions rising by 0.052916% when FDI rises by 1%, thus degrading the environment. The probability value for FDI is 0.0000, which shows its significant effect. Similar results were found by Khan et al. (2021), where FDI caused increases in CO2 emissions. The long-run outcomes explain, the GDP, FDI and NONRNW have a substantial positive relationship with CO2. This shows that GDP, FDI and NON-RNW increase CO2 emissions increase. The RNW negative but insignificant impact on CO2-emissions

Short Run result

The panel ARDL technique is employed, and outcomes of short-run is very important for the interpretation of this research analysis. To identify the short-run association between the series, the ECM test is employed.

Table 5.7 Short run (SR) results and Co-integration Equation:

SR-Equation				
Series	**Coefficient**	**Std. Error**	**t-Stat**	**Probability**
COINTEQ01	-0.324724	0.169215	-1.918999	0.0595
LOG NONRNW	0.278064	0.144743	1.921082	0.0592
LOG RNW	0.222184	0.302487	0.734525	0.4654
LOG GDP	-0.086512	0.120636	-0.717127	0.4759

LOG FDI	-0.006174	0.008331	-0.741052	0.4614
C	-2.275399	1.163656	-1.955388	0.0550

The first thing in the above table is the cointegration equation. It reveals the degree of adjustment of the model towards-equilibrium. Here, probability of the cointegration equation is 0.0595, which shows it is significant, and the coefficient of the cointegration equation is -0.324724. Here the negative sign shows moving away from disequilibrium and getting close to equilibrium; the value of -0.324724 shows that there is a 32% adjustment towards equilibrium in this model. In the short run, NONRNW is positively and significantly related to CO2. RNW is insignificantly and positively related to CO2. GDP and FDI are negatively and insignificantly related to CO2. The short and long-run outcomes frequently differ and it effects many variables have not yet matured in the short run, and a longer time period is required to obtain the full impact of the series.

Conclusions:

The study concludes that, the long-run results, NONRNW, GDP, and FDI cause harm to the environment by increasing CO2. On the other hand, RNW decreases CO2, but it is insignificant while other variables are significant. The Pedroni Panel Cointegration Test findings reveal long-run cointegration of a series, while the CD test outcomes demonstrate the existence of CSD. We have applied many tests, which show the following results: The correlation matrix shows how variables are correlated to each other. The outcome indicated whether the variables were positively, negatively, or strongly correlated with one another. The outcomes illustrate, the response variable NONRNW has a robust positive association with the dependent variable carbon dioxide, as does RNW. FDI is also strongly and positively correlated with its dependent variable, carbon dioxide. It is also discovered that RNW and NON-RNW direct associated with one another. The NONRNW and GDP is strong and direct association, as well as GDP and RNW is positive and strong relationship. The CD test revealed that all variables are significant, indicating that CSD exists in these series. This cross-section is linked to the others. They affect each other, and they depend on each other. The outcomes of the long-run relationship show that there is a direct link between the regressor series NONRNW and the regressand series CO2. Increases in NONRNW lead to increases in carbon dioxide. The long run outcomes that RNW causes carbon dioxide levels to fall. GDP is directly linked to *carbon dioxide. An increase in GDP rises CO2-emissions. FDI is positively associated to the dependent variable; an increase in FDI will raise CO2 emissions. A short-run test proved that NONRNW is positively* and pointedly connected to CO2 emissions. RNW is insignificantly and positively related to carbon dioxide. GDP and FDI are negatively and insignificantly related to carbon dioxide. Based on the findings of these tests, we must implement the following policies and consider their policies implications.

Policy implications:

The following are some of these strategies: the countries under study must introduce laws that make less and less use of nonrenewable energy sources. Therefore, fines, penalties, and taxes must be imposed on anyone using nonrenewable energy above the selected threshold level. Practical implications must be employed in order to attract the masses to use renewable energy sources more. Subsidies and incentives must be given to people for using renewable energy, and it should be made cheaply available. The government must focus on ways to spend GDP on non-polluting activities. People must be made aware of their environmentally harmful activities. FDI must be spent on green technology and clean production processes so that their use does not cause environmental degradation.

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