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DYNAMICS OF FORMAL AND INFORMAL INSTITUTIONS ON ENVIRONMENTAL QUALITY IN PAKISTAN

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ABSTRACT

Environment and economic growth have been interlinked with each other since the beginning of mankind. The institutions (formal and informal) play an important role in the determination of the relationship between income and the environment. Many indicators measure the environment, i.e., air, land, water, and emissions. There is a need to develop a comprehensive measure of environmental quality, measuring all dimensions. The study aimed to develop a multidimensional and comprehensive measure of environmental quality and to analyze the role of formal and informal institutions on the environment and economic growth. Furthermore, the policy measures are suggested based on the results of the study. The environmental policies are better reinforced through good governance and improved institutional quality. To achieve these objectives, secondary data has been used from different international agencies of developed and developing countries with a special focus on Pakistan. The long-run and short-run relationships have been identified by using co-integration analysis and causality analysis. The results of the empirical analysis show that Institutional quality exerts a positive impact on economic growth. Further, Economic growth follows a decreasing trend in CO_2 emissions, which validates the existence of EKC theory. The study also found that better institutions/policies cause higher income and improved environment in the long run, although it hampers growth in the short run. The study considers the vital roles of economic growth, institutional quality, and public awareness for a sustainable environment. To facilitate sustainable development in Pakistan, policymakers should be encouraged to prioritize policy design and implementation.

Keywords: Formal institutions; Informal institutions; CO_2 emissions; Environment; Pakistan.
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INTRODUCTION

The world is facing many climatic changes, and there is a lot of debate in the literature regarding the effects of climate change in the coming century. Climate change is caused by the depleting environmental quality or abrupt changes happening due to anthropogenic activities of humankind. The total world population is reaching up to 8 billion in 2019 from 6 billion in 2000, and South Asia is home to almost 1.83 billion people (World Bank, 2020). South Asia is an area that has experienced tremendous growth, prosperity, and development. It has a long history of deep bonding in its community. The world has globalized and liberalized after the evolution of new technologies and its associated costs are borne by this planet. One's actions are affecting others also. Many of the world's biggest polluting countries are not signatories or have not rectified the global climate change accords.

Pakistan is blessed with everything from the world's highest peaks and largest glaciers to water beaches. Because of increased energy consumption, industrialization, urbanization, and economic development in the region, pollution is growing at an exponential pace (UNEP, 2009). Since the ecological movement of the 1970s, the population has grown dramatically, from 700 million in 1970 to 1.85 billion in 2019, accounting for almost one-fourth of the world's overall population (World Bank, 2020). The economies have been transformed from subsistence agriculture to industrialization, leading to more urbanization and quality of life has been improved, resulting in higher energy demands and a strain on natural capital. The industrial development in the region has resulted in a slew of environmental issues, including poor air quality, water pollution, deforestation, and climate vulnerability.

Air pollution is rising at an unprecedented pace in the world and Pakistan because of rapid urbanization and the expansion of their economies' utility and manufacturing sectors. Many gases, such as SO_x, NO_x, and Carbon oxides, are found in the air as tiny particles, and their elevated exposure will cause significant health issues such as respiratory diseases, acid rain, and atmospheric browning clouds. CO_2 is a major greenhouse gas (GHG) and a major contributor to global warming. CO_2 alone accounts for almost 80% of global GHG emissions (Solomon et al., 2007). As several scholars contend, developed countries are outsourcing their "dirty business" to developing countries due to cheap labor and lower environmental requirements, which supports the "pollution heaven theory" that trade openness will impact the atmosphere both positively (Antweiler et al., 2001) and negatively (Wijnbergen, 1984). Increased population puts more strain on natural resources, resulting in deforestation (Cole, 2004). Sulfur Dioxide (SO2) is another significant pollutant that can cause acid rain and brown clouds in the atmosphere (Klimont et al., 2013). Significant causes of SO2 in SAARC countries include increased agricultural emissions and the use of coal in power plants (UNEP, 2009). Figure 1 shows the trends of per capita carbon emissions and population density over time in Pakistan.

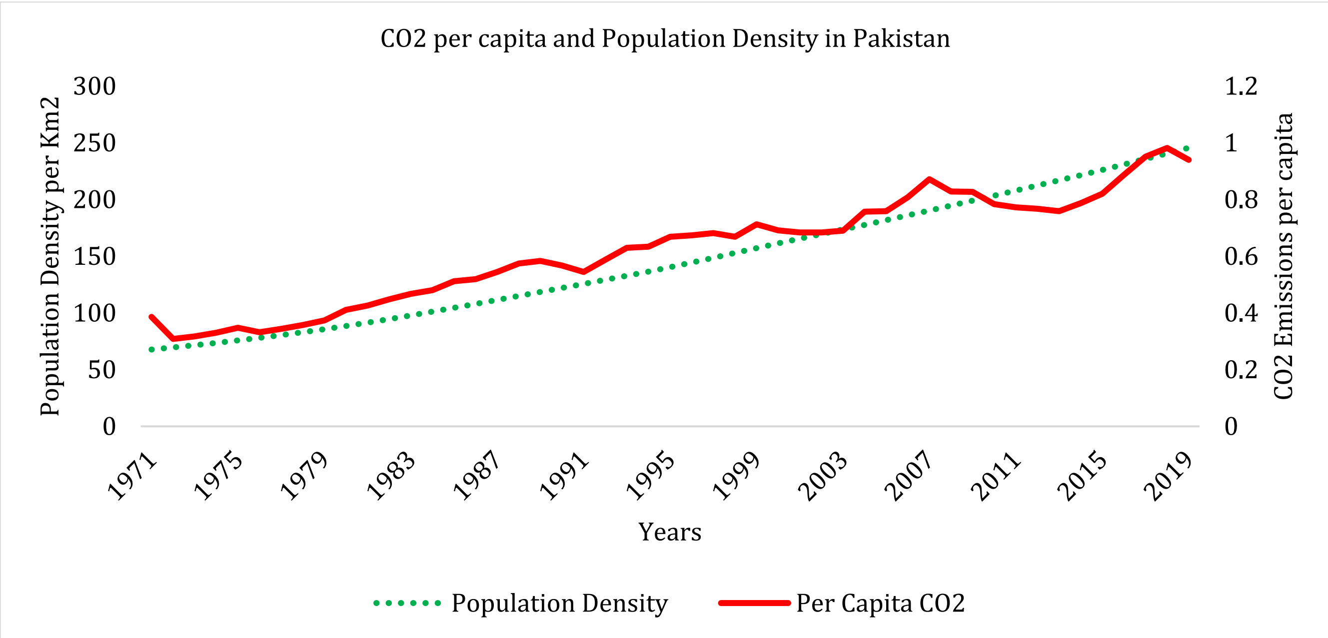

Figure **Error! No text of specified style in document.**. Per capita CO_2 metric tons emissions and population density in Pakistan; Source: Author's illustration from World Development Indicators Data (World Bank, 2020).

Figure 1 shows that the carbon emissions per capita have increased over time in Pakistan, and it is showing an increasing trend along with the increased population density of 68 per person per square kilometer to 246 persons per square kilometer, leading to increased ecological footprint and asserting more pressure on the natural resources.

There is a lot of debate in the literature on EKC. Some studies call it a very useful policy tool, while others have raised many concerns about the methodology and indicators used for environmental quality.

However, it is beyond the scope of this study to discuss methodological issues of EKC; it provides useful insight from an institutional perspective and highlights the importance of cooperation at the regional level. Stern (2004), Dinda (2004), Kaika and Zervas (2013a), and Kaika and Zervas (2013b) provided a complete survey of previous studies, while Kijima et al. (2010) discussed the economic models used in EKC literature and pointed out to develop them theoretically with a policy perspective.

Panayotou (1997) introduced policy variables in EKC and found that better institutional quality may lower income levels, after which pollution levels start declining. He argued that without the inclusion of the role of policies, EKC is a "black box" that is hiding more than it reveals and cannot be used as a policy tool. Civil liberties and political rights are more important determinants of pollution in low-income countries than income. In developing countries, power inequality may be a cause of pollution (Torras & Boyace, 1998).

To the best of my knowledge, it is the first attempt to study the impact of institutional quality on the income-pollution relationship in the SAARC region. In addition, the study analyzed whether either EKC holds or not for the region. This study attempts to fill the research gap by providing useful insights for policymakers to improve cooperation at the regional level and highlights the impact of better political institutions and quality of governance on environmental quality. The study will have the following specific objectives: To analyze the role of institutions (formal and informal) on environmental quality and income in Pakistan. There is a need to state the limitations of the study. The current study will have data limitations. The indicators measuring different dimensions of the environment could be changed according to the data availability, but it will not affect the objective of the study to develop a new methodology to measure environmental quality.

REVIEW OF LITERATURE

The dynamic nature of the economic growth-environment relationship, in the context of EKC theory, offers a useful conceptual framework for the intricate interplay between ecological well-being and economic prosperity. EKC structured the link between carbon emissions and per capita income like an inverted U. As with an increase in GDP, environmental degradation goes up, but after a certain threshold, environmental degradation starts reducing, as shown in Figure 1. With the advancement in literature, EKC has changed many shapes. Numerous studies estimate the validity of the EKC hypothesis and its possible shapes in considered regions. Isik et al. (2019) estimated the EKC hypothesis for 50 US states deploying AMG and CCE techniques over the period of 1980 to 2015. They also investigated the negative impact of fossil energy consumption detected in all states except Texas. EKC hypothesis verified in 14 states suggests a U-shaped inversion between income and GDP while on carbon dioxide output renewable energy shed positive impact as shown in US states. The empirical findings help policymakers view their energy policies and renewable energy consumption that can affect their environment.

Bilgili et al. (2016) examined the revisited EKC hypothesis on environmental quality in OECD countries from 1977 to 2010, deploying FMOLS and DOLS estimators. This paper empirically examined inverted U-shaped EKC; EKC does not depend on the income level of any individual country. GDP per capita impacts CO2 emissions positively; in addition to this, renewable energy consumption supports a negative impact on CO_2. Al-Mulali et al. (2015) estimated the EKC theory employs the ecological footprints of environmental degradation using panel data for 93 countries. The paper examined that the EKC hypothesis exists in the middle to high-income countries in the stage of economic development, making the availability of technology possible to improve energy efficiency, energy saving and renewable energy. EKC hypothesis was not found in countries with low income. As noted, an inverted U-shaped relationship results when countries have a high level of economic development.

Balin and Akan (2015) examined EKC theory with the effect of innovation and industrial production in 27 developed countries for the time span 1997 to 2009, applying panel data methodology. Finding the confirmed existence of an N-shaped EKC between GDP per capita and carbon dioxide output emphasizes that CO_2 can be more severe after achieving a certain level of GDP instead of reducing CO_2. Industrial production positively impact CO_2 emissions as this sector is a major contributor to CO_2 emissions, whereas Research and Development positively impact CO_2 and encourage more innovation; in addition, Eco-friendly industrial policies should be adopted to address environmental concerns.

Kaika and Zervas (2013a) reviewed the evolution of EKC and the possible causes of EKC pattern. Many studies attempt to explore the significance of factors other than income that led to EKC pattern. There is a huge literature on EKC patterns, including international trade, structural changes, equity of income distribution, technical progress, and the institutional framework. Likewise, many studies deal with CO_2 emissions, indicating that CO_2 is not reduced by economic growth. Chowdhury and Moran (2012) proposed a study to critically review EKC hypothesis, its contribution, and gaps in the literature. A case study based on forest transition conducted in Mexico and Brazil revealed the operational framework offered by EKC for environmental development at national and regional scales.

Bo (2011) verified a literature survey of EKC explanation evidence, applying panel data as a more reliable way to pave environmental change is using panel data or time series data. In EKC hypothesis, environmental degradation is linked with per capita income. Environmental quality directly affects human health, which can improve through an increase in per capita income, but a higher income level fails to reduce environmental pollution or degradation. Environmental quality is not only measured by income, but there are also many variables that should be considered for measuring environmental change.

Dinda (2004) examined that EKC theory observed a U-shaped inversion among revenue and pollutants. EKC emphasizes that measuring environmental degradation with EKC perspective is only one way. No single policy is enough to reduce environmental degradation. As it is a multifaceted issue and linked with economic growth in many ways, Stern et al. (1996) critically examined EKC hypothesis by considering numerous studies based on EKC with different variables. EKC posits a significant relationship between CO_2 emissions and GDP. The finding suggests that this hypothesis is based on the assumption that per capita income should be equally distributed around the globe, whereas in reality, median income is less than mean income. Wang et al. (2023) examined EKC hypothesis with variables of income inequality, including renewable energy consumption, urbanization, and trade openness in 56 (HICS, UMICS, LICS) countries from 2003 to 2008. EKC postulates that with an increase in economic growth, CO_2 also increases after a threshold point following a decreasing pattern. Income inequality doubled the threshold effect that changed the conventional EKC shape to an N-shaped relationship that postulates exacerbating CO_2 emissions.

Voumik et al. (2023) estimated linkages between nuclear energy, urbanization, and human capital index, service sector, CO_2 emissions based on EKC hypothesis in BRICS countries that adopted CS- ARDL framework from 1972 to 2021. BRICS is a middle-income group still striving with pollution and environmental degradation; it needs long-term solutions for environmental sustainability and growth. Inverted U-shaped EKC hypothesis present between Environmental pollution and GDP. The paper examined that urbanization and GDP are positively related to CO_2 emissions while the nuclear energy sector is negatively related. Interestingly, in the short run, the human capital index is positively related to $CO_{2,}$ whereas it is negatively related in the long run.

Aydin et al. (2023) analyzed Nano-technological innovation energy consumption, including economic growth and ecological footprints for G-7 countries from 1990 to 2018, deploying a panel co-integration approach. Findings confirmed long-term correlation. Nanotechnology releases Nanoparticle emissions that negatively affect human health and the environment in the long term. EKC hypothesis exists in US, in Italy, and Japan, renewable energy consumption increased. The government should go deeper into particle emitting technology to foster economic growth along with an increase in renewable energy consumption.

Pata and Kartal (2023) examined the EKC and LLC hypothesis in case of South Korea by adopting DOLS and CCR estimator for the time span 1977 to 2018. South Korea is a developed economy; expansion in economic growth pollution hit the highest level. Findings showed the confirmed minimum inflation points found for carbon emissions and ecological footprints. Moreover, South Korea needs a higher income level to increase its load capacity as inflation points for LC are greater than the other two. LCC and ELC hypothesis exists in South Korea. Noted that renewable energy does not show any impact on environmental quality; only nuclear energy has the capacity to improve environmental quality in the long term.

Jahanger et al. (2023) analyzed the influence of nuclear energy in EKC framework alongside factors like human capital and military expenditure. The EKC shape directs a relationship between environmental sustainability and economic activities. N-shaped EKC exists in top nuclear energy-producing nations, revealing that the energy sector of these nations is highly dependent on non-renewable energy sources. The article utilized annual time series data for the time span 1990 to 2018 with a dynamic common correlation effect approach. Postulates that human capital and nuclear energy have a positive impact on environmental quality. Interestingly, a negative correlation is suggested between military spending and human capital with ecological footprints.

Mehmood (2022) observed EKC existence related to biomass energy consumption and ecological footprints in SAARC countries with additional variables of globalization natural resources applied OLS and DOLS techniques from 1990 to 2016. An empirical finding does not find EKC existence in SAARC countries, showing linear results in relation to all studied variables. Biomass energy consumption has increased ecological footprints along with globalization and natural resources. Pata (2018) investigated dynamic linkages among carbon emissions, urbanization, economic growth, and financial development in Turkey based on the period of 1974 to 2014 employed ARDL, Hatemi-j, Gregory-Hansen. The study found that the Co-integration test found a long-term relationship in variables. EKC demonstrated a U-shaped inversion between economic growth and carbon emissions, whereas economic growth showed an increase in CO_2 emissions. Considering CO_2 emissions, renewable energy is not an appropriate choice because hydropower energy consumption and renewable energy sources have no discernible effect on CO2 emissions. The conclusion made that Turkey is still far away from a certain level of GDP that is enough to reduce environmental pollution.

Zhang et al. (2017) proposed a study for Pakistan to estimate the co-integration relation between renewable energy, non-renewable energy, economic growth, and CO_2 emissions for the time span 1970 to 2012 and employed ARDL model. The empirical finding confirmed the existence of EKC hypothesis in case of Pakistan. EKC postulates that better economic growth leads to higher CO2 emissions, although renewable energy plays a pivotal role in reducing carbon dioxide emissions; on the other side, nonrenewable energy sources promote pollutants. Kurniawan et al. (2021) observed the link between economic growth and the environment, focusing on the natural capital employ panel data from 1990-2014. The study suggests that environmental and economic growth are interconnected. Countries with low levels of natural capital, facing depletion of resources, increase in carbon emissions, and the environment are negatively affected by economic growth. With abundant natural resources, a country can achieve both economic growth and environmental sustainability.

Liu et al. (2021) examined the impact of urbanization, carbon emissions and economic growth on the environment. Panel methodologies have been used to investigate the relationship for the period 1995-2014 in Northeast Asian Countries. Findings confirmed that urbanization and economic growth negatively impact the environment due to increased pollution and resource consumption. However, they also found that renewable energy use reduces greenhouse gases and other pollutants, which positively impact environmental quality. Shah et al. (2020) analyzed renewable and nonrenewable energy sources and institutional quality impact on the environment and economic activity using ARDL, FMOLS, DOLS, and other econometric techniques for a time span from 1990 to 2016 based on D-8 countries. Estimation confirmed that renewable and nonrenewable energy consumption positively contributes to economic growth, including environmental degradation. In addition, institutional quality positively impacts economic growth along with environmental quality.

Tiba and Omri (2017) find casual linkages between energy, economic growth and the environment by adopting panel data analysis from 1978 to 2014. This paper examined the existing literature findings, including EKC, to provide valuable insights for policymakers toward sustainable growth. Baek and Kim (2013) confirmed the notion of EKC for Korea adopted dynamic Co-integration based on energy consumption. The article examined the negative impact of thermal power production on carbon emissions, although nuclear energy production showed a significant impact on carbon emissions. In addition to this, energy consumption poses a noxious relationship with CO_2 in both the short and long run.

Conceptual Framework

The ecological relationship, also known as the Environmental Kuznets Curve, is the subject of much further discussion in the literature (EKC). The controversy about EKC is beyond the reach of this study. Institutions play a critical part in enforcing policies and promoting economic development. Weaker institutions result in lower productivity and, as a result, poor environmental quality. Several indexes assess the quality of air, soil, water, industrial waste, and agricultural pollution. These indexes each calculate a particular aspect of the world. There is a need to create a robust Environmental measure that evaluates all dimensions at the same time.

The Income and environment relation relates to the seminal work by Simon Kuznets (Kuznets, 1955), where it was explained that income inequality increases with income and then starts decreasing after a certain level. Grossman and Krueger (1995) conducted research into the interaction between economic development and the environment and discovered an inverted U-shaped relationship between income per capita and the environment. By regulating trade, imposing tariffs and limits, and levying direct and indirect taxes, institutions and policies play a significant role in a country's economic development. Externalities to the environment are unavoidable. Externalities to the environment are an unavoidable consequence of economic development. Reduced environmental pollution at lower income levels is aided by institutions and environmental policy. Panayotou (1997) incorporated policy variables into the income-environment relationship, claiming that without them, the EKC (Environmental Kuznets Curve) would be a "black bo" with no details for policy interventions. The relationship between income and pollution is described as the Environmental Kuznets Curve (EKC), named after the Economist (Kuznets, 1955). Many studies have found that the EKC hypothesis holds for Pakistan (Ahmed & Long, 2013; Gokmenoglu & Taspinar, 2018; Zhang et al., 2017; Nasir & Rehman, 2011; Ahmed & Long, 2012), similarly for India (Tiwari et al., 2013; Usman et al., 2019; Sinha & Shahbaz, 2018), similarly for Bangladesh (Miah et al., 2011) and in selected SAARC countries (Rehman et al. 2012). The formal rules (laws, constitutions, property rights) and informal social rules (norms, beliefs, taboos) that regulate an individual's activities and social experiences are referred to as institutions North, (1990). In several surveys, the role of organizations in environmental matters is emphasized. Payne (1995) claims that democracy has a profound impact on environmental sustainability because it is more accountable to citizens, provides unrestricted access to information, raises public consciousness of environmental problems, fosters civil society, and fosters international cooperation. Among the explanatory variables, civil rights and political liberties could minimize the income impact in the EKC hypothesis (Torras & Boyce, 1998; Bhattarai & Hammig, 2001). Institutional quality affects the income-environmental relationship both in the long and short run (Panayotou, 1997; Midlarsky, 1998; Bhattarai & Hammig, 2001; Dutt, 2009). Corruption affects pollution directly and indirectly (Cole, 2007). More carbon dioxide emissions are generated in the world as a result of increased urbanization, population growth, and energy use. Economic disparity and development are also hampered by environmental pollution, so strong political institutions and governance are needed. The implementation of current and potential future policy is ensured by strong structures and good governance. Since the SAARC region is made up of developing countries, stronger institutions could lower the "environmental price" of economic development, lowering the so-called Environmental Kuznets Curve, which is the turning point of the income-environment relationship (EKC).

According to Rehman et al. (2012), corruption explicitly worsens environmental quality in selected SAARC countries, and the EKC tipping point occurs at lower levels where corruption is absent. Corruption cannot be a straightforward indicator of systemic competence on its own, but improved government and democratic structures help to strengthen policy and environmental laws. Since CO2 is considered a global pollutant, Dutt (2009) discovered that government, structures, and socioeconomic factors influence the income-pollution relationship. To the best of my knowledge, this study will be the first of its kind, which will examine the environment-growth-institutional quality nexus. This study will generate a new comprehensive index for environmental quality. It will also provide a new conceptual framework for the measurement of environmental quality.

METHODOLOGY

This study used the annual time series data from the fiscal year 1990 to 2019 of Pakistan at the national level. The annual data of carbon emission (CO_2) was taken in the standard format as in metric tons, and then it was converted into per capita carbon. The carbon emission data is collected from World Development Indicators (WDI)). The national income at the household level is estimated with real per capita GDP, while per capita energy consumption is estimated with per capita kg of oil equivalents. The annual time series data of carbon emission, per capita GDP and annual per capita energy consumption is taken from World Development Indicators (WDI) published by the World Bank. On the other hand, the annual time series data of institutional quality is collected from the International Country Risk Guide (ICRG) published by IMF, which combines the twelve sub-indices (Asif & Majid, 2018). In order to maintain reliability and consistency, all the data was transformed into a natural log (Shahbaz et al., 2017; Shahbaz et al., 2018). All the details of modeled variables are given in Table 1.

Table 1. Variable description for time series analysis.

Variable name	Variable measure	Time Period	Data Source
CO_2	Carbon emission per capita (metric ton)	1990-2019	WDI
Y	GDP per capita constant 2015 $US	1990-2019	WDI
IQ	Intuitional quality – a composite index obtained using PCA on 12 components of political risk rating	1990-2019	ICRG
EC	Kilogram of oil equivalent per capita	1990	WDI

Econometric Modeling

The analysis started with examining the stationarity of modeled data. Overall, the stationarity of time series data suggests the appropriate selection of the model. We initiated our analysis by employing the Zivot and Andrews (1992) unit root test to detect structural breaks within the dataset. Subsequently, we utilized the bound testing procedure, initially introduced by Pesaran (2007) and expanded upon through the methodologies outlined by Kripfganz and Schneider (2018), to investigate co-integration relationships among the variables under consideration. In order to estimate both short-term and long-term coefficients, we further employed the Auto-Regressive. Considering the primary focus of our study on long-run dynamics, the adoption of the ARDL methodology is a well-justified choice. To assess the relationship between the study's variables in Eq. (1), the ARDL method estimates the unrestricted error correction (UREC) as follows:

$$\Delta\big(ln(CO_2)\big) = \beta_o + \sum_{i=1}^{p}\beta_1\Delta\big(ln(CO_2)\big)_{t-1} + \sum_{i=1}^{q}\beta_2\Delta\big(ln(Y)\big)_{t-1} + \sum_{i=1}^{r}\beta_3\Delta\big(ln(IQ)\big)_{t-1} + \sum_{i=1}^{s}\beta_4\Delta\big(ln(EC)\big)_{t-1} + \lambda_1 ln(CO_2)_{t-1} + \lambda_2 ln(Y)_{t-1} + \lambda_3 ln(IQ)_{t-1} + \lambda_4 ln(EC)_{t-1} + \mu_t \quad (1)$$

Where Δ is the first difference operator; $\beta_1, \beta_2, \beta_3, and\ \beta_4$ represented the short-run results andλ_1, λ_2, $\lambda_3\ and\ \lambda_4$ showed coefficients of long-run; p, q, r, and s are the lag length; α_o is a constant value and μ_t means the error term.

The procedure of ARDL lies within four steps – first, the selection of appropriate lag of the underlying model using the Akaike Information criteria (AIC). The next step is to calculate the co-integration with the help of the F value. The equation of the null hypothesis is expressed as:

$H_o: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0,$ against the alternative hypothesis,

$H_1: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$

Following the pathways of Kripfganz and Schneider (2018) for the lower and upper limits, if the F-state exceeds the upper limit, the null hypothesis of no co-integration was rejected, which confirms the co-integration of the investigated variables. In the third step, the ARDL has pursued both long and short-run dynamics. The ARDL long-run dynamics equation can be written as:

$$ln(CO_2) = \beta_o + \sum_{i=1}^{p} \beta_{1i} \Delta\big(ln(CO_2)\big)_{t-1} + \sum_{i=1}^{q} \beta_{2i} \Delta\big(ln(Y)\big)_{t-1} + \sum_{i=1}^{r} \beta_{3i} \Delta\big(ln(IQ)\big)_{t-1} + \sum_{i=1}^{s} \beta_{4i} \Delta\big(ln(EC)\big)_{t-1} + \mu_t \quad (2)$$

Next, for estimation of the short-run coefficient of the study's variables, the following error correction models were estimated:

$$ln(CO_2)_t = \beta_o + \sum_{i=1}^{p} \beta_{1i} \Delta\big(ln(CO_2)\big)_{t-1} + \sum_{i=1}^{q} \beta_{2i} \Delta\big(ln(Y)\big)_{t-1} + \sum_{i=1}^{r} \beta_{3i} \Delta\big(ln(IQ)\big)_{t-1} + \sum_{i=1}^{s} \beta_{4i} \Delta\big(ln(EC)\big)_{t-1} + \theta ECT_{t-1} + \mu_t \quad (3)$$

Where θECT_{t-1} indicates error correction term, which shows the adjustment speed of long-run equilibrium after a shock in the short-run. The θECT_{t-1} the value must be negative and significant to meet the estimation criteria of the long-run equilibrium.

Below, we present the equations that govern our causality model:

$$\begin{bmatrix} ln(CO_2)_t \\ ln(Y)_t \\ ln(IQ)_t \\ ln(EC)_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \begin{bmatrix} \chi_{11}, \chi_{12}, \chi_{13}, \chi_{14} \\ \chi_{21}, \chi_{22}, \chi_{23}, \chi_{24} \\ \chi_{31}, \chi_{32}, \chi_{33}, \chi_{34} \\ \chi_{41}, \chi_{42}, \chi_{43}, \chi_{44} \end{bmatrix} * \begin{bmatrix} ln(CO_2)_{t-1} \\ ln(Y)_{t-1} \\ ln(IQ)_{t-1} \\ ln(EC)_{t-1} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \end{bmatrix} * (ECT_{t-1}) + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \end{bmatrix} \quad (4)$$

Where ECTt-1 indicates the error correction term in t time.

RESULTS AND DISCUSSION

Using a time series analysis of Pakistan for the time period of 1990 to 2019, Table 2 shows a descriptive statistic of the studied variables. It portrays mean, SD, skewness, kurtosis, maximums, and minimums. The skewness of an object refers to the degree of symmetry or, rather, lack of it. For a symmetrical data set, the appearance on both sides should be the same. However, the standard deviation was calculated to indicate data desperation. Data series with low kurtosis are considered light tailed, whereas data with high kurtosis is considered highest tailed, compared to a normal distribution. The presence of uniform distribution is an extreme example.

Analysis of Relationships

Table 3 revealed the results of a time series analysis of variables, demonstrating a positive association between GDP and CO_2 emissions, institutional quality, and energy usage. These findings are consistent with existing literature, suggesting that these variables jointly play a role in intricate economic development through time series and panel data analysis. Despite the fact that a strong and significant correlation exists between energy usage and CO_2 emissions with GDP growth, energy usage not only contributes to economic growth but also leads to an increase in CO_2 emissions. In addition to this, institutional quality is highly associated with carbon dioxide emissions and power usage.

Table 2. Statistical description of variables employing time series analysis.

Descriptive Stats	CO_2 per capita	GDP per capita	Energy Consumption	Institutional Quality
Minimum	0.5444	924.6347	397.0965	22.0446
Maximum	0.9818	1502.8913	500.4320	69.5435
Mean	0.7472	1162.7897	452.5059	46.0842
STD	0.1093	168.9809	24.2771	13.4076
Skewness	0.2973	0.4656	-0.5799	0.3019
Kurtosis	-0.3345	-0.9345	0.1992	-1.2887

Table 3. Results of correlation among variables using time series analysis.

Correl.	CO_2 per capita	GDP per capita	Energy Consumption	Institutional quality
CO_2 per capita	1			
GDP per capita	0.9463	1		
Energy Consumption	0.7864	0.6814	1	
Institutional quality	0.1189	-0.0664	0.5719	1

Unit Root Tests using Time Series Analysis

For accessing the stationarity of a given data series, this section employed unit root analyses. It facilitates in determining whether a time series is stationary or non-stationary and facilitates the selection of relevant co-integration tests for the accurate empirical model, ensuring the reliability of results. In previous studies, unit root test used are Augmented Dickey-Fuller unit root test (Dickey & Fuller, 1979), Phillips-Perron unit root test (Phillips & Perron, 1988), KPSS (Kwiatkowski et al., 1992) and N-Perron (Ng & Perron, 2001). The above-mentioned unit root tests are unable to detect structural breaks within time series data. In the absence of structural breaks, unit root test results are uncertain. In this regard, this study utilized the Zivot Andrews (ZA) unit root test for detecting structural breaks in given data. As Table 4 mentioned, the results of ZA unit root test analyzed variables as non-stationary at a 5% significance level. The findings of the unit root test do not reject the null hypothesis. After applying the first differencing, the null hypothesis will be rejected, whereas variables become stationary after the first differencing. It is worth noting that structural breaks fall within the time period of 1990 to 2019 align with timeframe during which Pakistan introduced its environmental policy - 1997 and modified it in 2003.

Table 4. Zivot Andrews unit root test.

Regressor	Level			First difference		
	T-Stat	Prob.	Break year	T-Stat	Prob.	Break year
$LnCO_2$	-4.207	0.636	2011	-6.455**	0.0019	2006
LnY	-2.782	0.216	2002	-5.552**	0.0124	1997
$LnIQ$	-4.415	0.201	1992	-5.119**	0.0240	1997
$LnEC$	-3.829	0.171	2010	5.799**	0.0299	2010

Note: * Level of Significance showed at 5%.

Results of Autoregressive Distributive Lag Model

Findings of ARDL Bound test are displayed in Table 5, indicating that F-stats in the model overlap the critical values of the upper bound, I(1), as assured in the study of Kripfganz and Schneider (2018). Hence, recommended rejection of the null hypothesis in case of no co-integration. Moreover, ARDL can be continued as variables of study are cointegrated.

Table 5. ARDL bound test results.

Model	10%		5%		1%		F-stat
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
$CO_2 = f(Y, IQ, EC)$	3.385	4.420	4.219	5.444	6.201	7.591	7.010**

Note: The level of significance showed at 5%.

The study proposed to examine both short and long-run dynamics after satisfying assumptions of ARDL. It must be noted that EKC analysis was conducted using the method of Narayan and Narayan (2010); it can mitigate the uncertainty of collinearity and multicollinearity (Sun et al., 2018). Long and short-run findings of ARDL are mentioned in Table 6. The long and short-run income coefficient (LnY) indicated statistically significant and positive by econometric findings, explaining that income increases lead to an increase in CO_2 emissions. Nevertheless, the elasticity of carbon emissions to income diminishes over time, particularly when the income impact reduces from 0.61 to 0.28. Affirmation of EKC in the context of Pakistan back up the notion that reduction in CO_2 emissions income can be beneficial. To curb CO_2 emissions, economic development is emphasized by prior policy recommendations. In this regard, the current study suggests that by fostering economic growth, environmental issues can be mitigated.

Results indicate that power usage has a significant impact on carbon dioxide emissions in Pakistan. Explanation of the industrial sector increases its energy demand along with reliance on non-renewable energy sources. To mitigate this, a transition towards cleaner energy is needed. Conversely, reduced dependence on fossil fuels-based sources is needed. Environmental Kuznets Curve (EKC) and energy consumption-related results are aligned with previous studies (Zhang et al., 2017; Shahbaz et al., 2012) in case of Pakistan. However, the study deviated in one aspect: in the presence of institutional quality EKC hypothesis validates. Table 6 mentions the results of institutional quality, demonstrates a statistically significant and positive coefficient for institutional quality, and also suggests mitigating effects for CO_2 emissions. Poor institutional performance in Pakistan posed challenges that evident low level of institutional quality such as political stability, accountability, governance, corruption, and rule of law directly affect institutions and implementation of policies. Better access to information and a high-quality environment are building blocks for improved institutional quality. Conversely, designing and implementing sound, environmentally friendly policies is hindered by a high level of corruption. In short, poor institutional quality in Pakistan attracts domestic and foreign investment even for more polluted industries, fostering non-ecofriendly technology transfer of outdated technology that ultimately boosts pollution. In a broader context, it is not compulsory that public policies always achieve their intended goals. Hence, the adoption of an integrated approach to a clean environment and reducing pollution is crucial, along with the aim of saving costs and avoiding objectives of overly regressive policies.

Institutional quality poses challenges to the total factor productivity of emerging economies and hinders their economic development (Feng et al., 2018). Institutions play a pivotal role in ensuring the effective implementation of environmental policies because of public awareness and the ecological concerns of organizations. In addition to this, institutional quality can contribute to natural resource consumption, yielding positive results on the environment (Baloch et al., 2019). Noted that these results contradict studies conducted by Salman et al. (2019) and Lægreid and Povitkina (2018) analyzed that higher organizational quality reduces carbon dioxide output. A study by Sarkodie and Adams (2018) estimated irrelevant relationships between organizations and environmental contamination for counting structural breaks detected by applying the Zivot Andrews unit root test in a given data series; a dummy variable was adjusted into the model. The negative impact of structural breaks can be associated with the Asian financial crisis in the late 1990s (Solarin & Shahbaz, 2015). Economic shock formed by the Asian crisis led to an energy demand reduction and reduced CO_2 emissions across Asia, including Pakistan.

Table 6. Results in long run and short run using ARDL.

Regressor	Long run		Short run	
	Coefficient	Prob.	Coefficient	Prob.
Constant	0.6125 *	0.0089	0.8447 ***	0.0869
LnY	0.2854 **	0.0210	0.2238 *	0.0041
LnIQ	0.6151 *	0.0083	0.0218	0.2910
LnEC	1.1958 *	0.0000	0.8796 *	0.0001
$Dummy_{2002}$	- 0.0985 *	0.0001	- 0.0349 *	0.0040
ECT_{t-1}	- 0.4112 **	0.0195		
F-statistics	1651.5 *	0.0000	1462.5 *	0.0000

Note: 1%, 5%, 10% significance level denoted through *, ** and ***; $R^2 = 0.989$ | D.W. = 1.943.

Variables diagnostic tests were conducted to affirm the stability of the model and outcomes, as shown in Table 7. Findings indicate the absence of heteroscedasticity, multicollinearity, and autocorrelation. In short, the model is fit, and the results of ARDL are considered reliable. CUMSUM and CUMSUMsq1, including sensitive analysis, are also employed to ensure the stability of the model.

Table 7. Results of diagnostic test.

Diagnostic test	F-statistics	Prob.
- *(serial correlation)*	2.3001	0.3314
- *(heteroskedasticity)*	1.7712	0.2012
- *(RESET RAMSEY)*	0.1928	0.879

Note: 1%,5% and 10% significance level denoted through *, ** and ***.

After estimating short and long-run parameters, the next step involves finding a causal relationship among studied variables, as mentioned in Table 8. In the long run, bidirectional causality is found in institutional quality and energy usage, between institutional quality and CO_2 emissions, and between energy usage and CO_2 emissions. These findings are aligned with the findings of Dauda et al. (2019).

Table 8. Analysis by using the Granger causality test.

Wald-statistics					causality in long run (t-stat)
Variable	$\Delta lnCO_2$	ΔlnY	$\Delta lnIQ$	$\Delta lnEC$	ecm_{t-1}
$LnCO_2$	-	5.5631 *	7.9851 *	- 3.1023 *	- 0.3927 *
LnY	0.9851	-	8.9112	- 1.3120	- 0.0895
LnIQ	1.4125	- 0.8105	-	- 1.8125 ***	- 0.2106 ***
LnEC	7.4125 *	2.2541 **	1.5123	-	- 0.4981 *

Note: 1%,5% and 10% significance level denoted through *, ** and ***.

Short-term causality, also mentioned in Table 8, exhibiting unidirectional causality runs towards CO_2 emissions. By the Vector Error Correction Model, this causality indicates the relationship between GDP and CO_2 emissions, elaborating that CO_2 not only depends on economic growth. On the other side, between CO_2 emissions and energy consumption, bidirectional causality exists, demonstrating the challenges faced by Pakistan in the decoupling of carbon emissions due to an increase in demand for fuel-based energy sources (Sun et al., 2018). Moreover, unidirectional causality was found between institutional quality and carbon dioxide emissions, indicating that institutional quality is an important tool for reducing CO_2 emissions.

CONCLUSIONS AND RECOMMENDATIONS

This study proposed to estimate structural changes that are interlinked with growth, CO_2, and institutional quality in the context of energy usage and CO_2 emissions. This research employs the ARDL approach with Granger causality test both for the short and long term. It is concluded that institutional quality exerts a positive impact on economic growth, and economic growth follows a decreasing trend in CO_2 emissions, which validates the existence of EKC theory. By contributing new insights for Pakistan, this study emphasizes the role of institutional quality in the environment. Institutional quality plays a crucial role in establishing a U-shaped inversion between income and pollution in Pakistan. Furthermore, aligning with previous research, the present research ensures the connection between energy usage and carbon dioxide emissions. Unidirectional causality in the short run is found between institutional quality and carbon dioxide emissions, whereas institutional quality and CO_2 emissions exhibit mutual Granger causation during the long run.

This study holds several implications for policymakers. Economic growth plays a constructive role in reducing pollution, as observed by the diminishing impact of income on pollution. It is recommended that the government should reshape its policies to reap the benefits of sustainable development. For institutional quality, these reforms are pathways to enhance the environmental quality of the country. The need of the time is to promote public awareness to generate increased demand for a sustainable environment. To achieve this, policymakers prioritize strategies that help to create awareness. Institutional quality can be an effective tool to reduce CO_2 emissions and mitigate climate change. For better performance of institutional quality, we need to combat corruption, regulate the rule of law, and enhance government efficiency. The study considers the vital roles of economic growth, institutional quality, and public awareness for a sustainable environment. To facilitate sustainable development in Pakistan, policymakers should be encouraged to prioritize policy design and implementation.

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