JBEO, Vol. 2(1), 35-44

Journal of Business and Economic Options

Exploring the Environmental Kuznets Curve: Economic Growth and CO2 Emissions Dynamics

Faisal Aftab Ahmed[a]

Abstract
This article aims to explore the relationship between CO2 emissions per capita and several key economic and environmental indicators, including gross domestic product per capita, trade openness, the number of vehicles, and the output of the services sector. This investigation is conducted within the framework of the Environmental Kuznets Curve, a hypothesized inverted U-shaped relationship between environmental degradation and economic development. By utilizing time series data spanning from 1972 to 2015, the dissertation seeks to analyze the long-term trends and dynamics of CO2 emissions and economic variables. The inclusion of a wide temporal scope allows for a comprehensive understanding of how economic growth, trade patterns, and technological advancements have influenced environmental outcomes over several decades. The primary focus is on examining the association between CO2 emissions per capita and GDP PC, as these variables represent the core elements of the ECK hypothesis. Additionally, trade openness is considered to assess the impact of international trade on environmental degradation. The number of vehicles is included as a proxy for transportation-related emissions, reflecting the role of urbanization and industrialization in shaping environmental impacts. Furthermore, the output of the services sector is analyzed to understand the contribution of different sectors to overall CO2 emissions. The essence of the results indicates the presence of an Environmental Kuznets Curve between CO2 emissions per capita and Gross Domestic Product per capita. This finding suggests that initially, as economic development progresses, CO2 emissions per capita tend to increase. However, beyond a certain threshold of economic growth, further increases in GDP per capita are associated with declines in CO2 emissions per capita, indicating a potential decoupling of economic growth from environmental degradation. Interestingly, the analysis reveals that the square of Gross Domestic Product per capita emerges as the only factor that contributes to environmental mitigation, indicating that certain levels of economic prosperity may facilitate the adoption of environmentally friendly technologies and practices. However, the study also highlights that other factors such as trade openness, the number of vehicles, and the output of the services sector are associated with exacerbating environmental pollution. Despite economic growth, these factors contribute to the overall pollution burden, suggesting the need for targeted policy interventions and technological innovations to address environmental challenges effectively.
Keywords: CO2 emissions, Economic growth, Environmental Kuznets Curve, Trade openness, Urbanization
JEL Codes: Q56, O44, F18

1. INTRODUCTION

The concept of "having our cake and eating it too," as described by Rees (1990), symbolizes humanity's desire to enjoy the benefits of economic growth and material prosperity without considering the environmental consequences. This mindset has led to a gradual pollution of the Earth's environment, driven by both the scale effect of economic growth and the rampant materialism prevalent in society. Social scientists argue that economic growth often necessitates increased energy and raw material consumption, resulting in the generation of significant quantities of byproducts. This process includes the extraction of natural resources, the accumulation of waste, water contamination, and the emission of CO2 and other pollutants, all of which contribute to the pollution of the air, water, and land. The relentless pursuit of economic growth and material wealth has led to unsustainable patterns of consumption and production, exacerbating environmental degradation and threatening the planet's ecological balance. The scale effect, driven by the expansion of economic activities, magnifies the environmental impacts, while materialism perpetuates a culture of excessive consumption and waste generation. Addressing these challenges requires a fundamental shift in societal values and priorities, moving towards more sustainable and equitable models of development. This entails reevaluating our consumption patterns, promoting resource efficiency and conservation, investing in renewable energy sources, and implementing policies that prioritize environmental protection and regeneration. By recognizing the interconnectedness of economic prosperity and environmental health, and adopting holistic approaches to sustainable development, humanity can strive to achieve a balance where prosperity is achieved without compromising the well-being of future generations or the health of the planet.

The activities mentioned indeed exert pressure on the biosphere, contributing to environmental degradation and ultimately leading to climate change. The consequences of this degradation are far-reaching and impact various sectors of the economy.

[a] Department of Economics, The Islamia University of Bahawalpur, Pakistan. Bahawalnagar Campus, Pakistan

For instance, in agriculture, changes in temperature and precipitation patterns can disrupt crop yields and reduce productivity. Additionally, increased air and water pollution can pose health risks to populations, resulting in higher healthcare costs and reduced labor productivity. Developing countries often bear a disproportionate burden of these negative externalities. Despite contributing relatively less to global pollution compared to developed nations, they experience significant economic and social costs associated with environmental degradation. This situation exacerbates existing challenges related to poverty, food security, and public health, hindering their efforts towards sustainable development.

The question of whether there are trade-offs between economic growth and environmental degradation remains unanswered and complex. While traditional economic models have often framed economic growth and environmental protection as conflicting objectives, there is growing recognition of the interconnectedness between the two. Sustainable development frameworks emphasize the need to pursue economic growth in ways that minimize environmental harm and maximize social well-being. Efforts to decouple economic growth from environmental degradation involve adopting cleaner technologies, promoting renewable energy sources, implementing pollution control measures, and integrating environmental considerations into policy and decision-making processes. These approaches aim to achieve a balance where economic development can occur without compromising the integrity of ecosystems or the health of current and future generations. Addressing the trade-offs between economic growth and environmental degradation requires a multidisciplinary and collaborative approach, involving governments, businesses, civil society organizations, and international institutions. By prioritizing sustainable development practices and embracing a mindset of environmental stewardship, societies can strive towards achieving harmony between economic prosperity and ecological integrity.

The complete elimination of environmental problems remains a challenging task, and in the 1990s, environmental degradation garnered significant attention from economists (Rees, 1990). Recent studies have highlighted the substantial contribution of CO_2 to pollution, prompting a growing emphasis on environmentally friendly growth strategies. A plethora of literature has underscored a common perspective: environmental deterioration is initially positively correlated with a country's economic fortune, but as development progresses, the situation often reverses. The Environmental Kuznets Curve (EKC) concept elucidates this relationship, depicting a systematic pattern between different pollutants and income per capita. Initially, environmental degradation worsens as economies industrialize, but as they advance further, environmental conditions tend to improve. This relationship is often illustrated as an inverted "U" shape, signifying a transition from pollution-intensive industrialization to a more service-oriented economy. Research on the EKC is primarily empirical, but criticisms have emerged regarding both theoretical and conceptual aspects (Incidentstern, 2004; Wagner, 2015). Some scholars argue that improper econometric techniques or unsuitable methodologies have been employed to support the EKC hypothesis. However, when correct statistical methods are applied, studies often fail to observe the EKC phenomenon (Perman and Stern, 2003). Instead, they find a continuous increase in pollution levels, particularly for pollutants like CO_2, SO_2, CO, and NO_X. In essence, while the Environmental Kuznets Curve has been a subject of debate and criticism, its empirical validity remains uncertain. The complexities of environmental-economic interactions warrant further research and nuanced analysis to develop effective policies for sustainable development and pollution mitigation. The discussion on appropriate techniques and strategies for model specification in the context of the Environmental Kuznets Curve (EKC) is crucial for understanding the complex relationship between economic growth and environmental degradation. However, reaching a consensus among economists on this matter has proven challenging, as evidenced by the diverse perspectives put forth by researchers such as Perman and Stern (2003), Galeotti et al. (2006), Dinda and Coondoo (2006), Harbaugh et al. (2002), Jalil and Muhammad (2009), and Wagner (2015).

Environmental degradation, being a global issue, is intricately linked to climate change and can significantly impact agricultural output, particularly due to seasonal variations. To address these complexities, the study incorporates additional data spanning two years beyond those used by previous researchers and introduces the services sector output as an explanatory variable. This addition aims to provide a more nuanced understanding of the variability in the economy and its relationship with environmental degradation. To test environmental degradation, the study utilizes time series data covering the period from 1972 to 2014, sourced from various official websites such as the World Development Indicators, the Handbook of Statistics published by the State Bank of Pakistan, and various economic surveys on Pakistan's economy. The methodology employed in the analysis will depend on the stationarity levels of the variables under consideration, ensuring robustness and reliability in the estimation process.

The primary objective of this study is to empirically investigate the existence of an inverted "U"-shaped Environmental Kuznets Curve (EKC) in Pakistan. This curve represents the hypothesized relationship between economic development and environmental degradation, suggesting that environmental quality initially deteriorates as economic growth accelerates, but eventually improves once a certain level of income is reached. By examining data specific to Pakistan, the study aims to determine whether such a pattern holds true in the context of the country's economic and environmental dynamics.

2. CONCEPTUAL AND THEORETICAL BACKGROUND

The emergence of the Environmental Kuznets Curve (EKC) is closely linked to debates surrounding economic growth and related policies. Previous research and dissertations have often highlighted the idea that as income levels increase, environmental pollution also rises initially, but eventually declines once a certain threshold of income is surpassed. This perspective suggests a nuanced relationship between economic growth and environmental quality, where the impact of economic activity on the environment changes over time. Beckerman's work in 1992, for instance, emphasized this concept by proposing that higher income levels may initially lead to increased environmental pollution before contributing to environmental improvement at more advanced stages of economic development. The potential of economic growth to positively influence global pollution has been a topic of discussion in the literature, as noted by Panayotou in 1993. However, the question of which type of economic growth contributes to environmental preservation remains open to debate. The relationship between economic growth and environmental pollutants, as explored through the Environmental Kuznets Curve (EKC), has been a subject of prolonged discussion and analysis.

Before the 1970s, economists generally held the belief that economic growth was positively correlated with the consumption of raw materials. However, the emergence of the Club of Rome's "limit to growth" perspective challenged this notion by highlighting the finite nature of raw materials. This perspective raised concerns about the sustainability of traditional economic growth models. Critics of the traditional viewpoint on economic growth and raw material consumption pointed out empirical and theoretical weaknesses in the argument. These criticisms spurred further debate and analysis, leading researchers to explore alternative frameworks for understanding the relationship between economic growth and environmental sustainability.

Panayotou (1993) was among the pioneers who conceptualized the Environmental Kuznets Curve (EKC), offering a framework to understand the dynamic relationship between economic growth and environmental degradation. The EKC hypothesis suggests an inverted U-shaped relationship between per capita income and environmental pollution, implying that pollution initially increases with economic growth but eventually decreases after reaching a certain income threshold. The impact of economic growth on the environment can vary depending on several factors, including the level of environmental awareness and the adoption of environmentally friendly technologies. While economic growth may initially lead to an increase in pollution due to higher levels of production and consumption, beyond a certain income threshold, societies may become more environmentally conscious and invest in cleaner technologies and sustainable practices. This shift can contribute to a decline in pollution levels despite continued economic growth.

3. LITERATURE REVIEW

The groundbreaking work of Grossman and Kruger (1992) opened up new avenues in the environmental discourse by shedding light on the phenomenon where environmental degradation initially increases but then declines as income levels rise. This concept, later coined as the Environmental Kuznets Curve (EKC), garnered significant attention from economists and researchers alike. Since then, numerous studies have contributed to our understanding of the EKC and its implications. Scholars have examined various aspects of the relationship between economic growth and environmental degradation, exploring factors such as income levels, technological advancements, policy interventions, and institutional frameworks. The scope of the Environmental Kuznets Curve remains a topic of debate and inquiry within the academic community. Researchers continue to explore its applicability across different countries, regions, and environmental indicators, seeking to uncover nuances in the relationship between economic development and environmental quality. In the present part of the article, we will delve into the essence of previous literature on the Environmental Kuznets Curve, synthesizing key findings and discussing the evolving understanding of this complex relationship.

Ahmed and Long (2012) conducted an empirical analysis of the Environmental Kuznets Curve (EKC) in Pakistan, utilizing time series data spanning from 1971 to 2012. Their study revealed a significant relationship between the economic prosperity of the country and pollution indicators. They concluded that there is a notable existence of the Environmental Kuznets Curve phenomenon in Pakistan. The researchers attributed environmental degradation in Pakistan to various factors such as low levels of gross domestic product (GDP), high energy consumption, trade openness, and population density. Conversely, they found that higher levels of per capita income were associated with improvements in the environment. As a policy recommendation, the researchers proposed the implementation of regulations targeting traffic emissions to mitigate environmental deterioration. Their findings underscored the importance of economic growth accompanied by appropriate environmental policies to achieve sustainable development goals in Pakistan.

Shahbaz et al. (2005) conducted a study on the Environmental Kuznets Curve (EKC) and the impact of energy consumption in Pakistan, employing the Auto Regressive Distributed Lag (ARDL) technique. Their analysis utilized time series data spanning from 1971 to 2009, aiming to uncover the relationship between CO2 emissions and energy consumption. The study revealed that energy consumption had a significant detrimental effect on the environment in both the short and long run. However, it found that trade openness had a positive impact on the environment in both time periods studied. Ultimately, the research concluded the existence of the Environmental Kuznets Curve phenomenon in Pakistan over both short and long time periods. The study's policy recommendations included suggestions for importing cleaner technology, reevaluating the scale effect, and transitioning towards a green economy. These recommendations aimed to address environmental degradation while promoting sustainable development in Pakistan.

Ali et al. (2014) introduced a new economic perspective on the Environmental Kuznets Curve (EKC) in Pakistan through a time series analysis spanning from 1972 to 2011. Utilizing the Auto Regressive Distributed Lag (ARDL) technique, the researchers examined the stationary nature of certain variables at different levels. The study aimed to validate the existence of the Environmental Kuznets Curve in the context of Pakistan. It corroborated the findings of previous studies regarding the EKC, indicating satisfaction with the established framework. Moreover, the research emphasized the necessity of sustainable economic development for addressing environmental degradation. It recommended a focus on public investment and the promotion of Gross Domestic Product (GDP) growth as crucial initiatives for improving the poor quality environment in Pakistan.

Ismail et al. (2014) conducted a study on the Environmental Kuznets Curve (EKC) and sulfur dioxide (SO2) emissions in Pakistan, employing the Auto Regressive Distributed Lag (ARDL) estimation technique. The researchers aimed to clarify the relationship among SO2 emissions, energy consumption, trade liberalization, and population density in Pakistan. The study utilized time series data from 1970 to 2008 to analyze the dynamics of these variables. According to their findings, real income, trade liberalization, and energy consumption were positively correlated with SO2 emissions. However, population growth and the growth in Gross Domestic Product (GDP) were associated with improvements in the environment. Additionally, trade openness was found to have a positive impact on the environment, particularly in the long run.

Fan and Zheng (2013) investigated the relationship between economic growth and the environment in Sichuan province, China. The study aimed to determine whether the Environmental Kuznets Curve (EKC) declined in Sichuan province as per capita income increased. The researchers utilized quadratic and cubic models to explore this relationship and test theoretical perspectives. Their findings revealed that the quadratic model supported the existence of the Environmental Kuznets Curve, while the cubic model emphasized an inverted N-shaped curve. The study concluded that environmental improvement was closely related to awareness and efforts for the betterment of the environment rather than solely to income growth.

The study by Shahbaz et al. (2013) shed light on the intricate relationship between economic development and environmental sustainability. By utilizing advanced econometric techniques, such as the Auto Regressive Distributed Lag (ARDL) bound test, they provided robust evidence supporting the existence of an Environmental Kuznets Curve (EKC) for pollutants. Their findings have significant policy implications, suggesting that as economies progress and income levels rise, environmental degradation tends to peak and then decline. This underscores the importance of prioritizing sustainable development strategies that balance economic growth with environmental protection. Moreover, their recommendation to invest in green technologies and transition to cleaner energy sources reflects a forward-thinking approach to address environmental challenges while fostering economic growth. By embracing renewable energy and sustainable practices, countries can mitigate pollution levels and promote long-term environmental sustainability.

The study by Chaudhuri and Pfaff (2004) offers an intriguing perspective on the relationship between income levels and environmental behavior. Their findings suggest that wealthier individuals tend to consume more cooking and heating services, while poorer segments of society spend less on these services. This consumption pattern leads to differential environmental impacts, with affluent individuals potentially exerting greater pressure on the environment through their consumption habits. The researchers propose that this disparity in environmental impact arises from the purchasing power of wealthy individuals, who are more likely to afford the latest environmental-friendly technologies. In contrast, poorer individuals may lack access to such technologies and rely on less efficient and more polluting alternatives for cooking and heating. This study highlights the complex interplay between income inequality and environmental degradation, suggesting that addressing environmental challenges requires considering socio-economic factors. By understanding how consumption patterns vary across different income groups, policymakers can develop targeted strategies to promote sustainable consumption practices and reduce environmental harm.

In the study conducted by Cole and Neumayer (2004), the researchers investigated the relationship between demographic factors and pollution levels. Utilizing cross-national data, they aimed to discern the extent to which CO2 emissions and population growth were interrelated. Their analysis revealed that CO2 emissions and population growth exhibited a unitary elastic relationship, indicating that as the population increased, CO2 emissions also rose proportionally. Additionally, the researchers examined the impact of urbanization and household size on pollution levels. They found that urbanization and smaller household sizes were contributing factors to increased pollution. However, the results presented in the study's tables showed that these indicators were statistically insignificant, suggesting that the observed relationships may not have been robust or strong enough to draw definitive conclusions. Despite this, the study provided valuable insights into the complex interplay between demographic dynamics and environmental pollution, highlighting the need for further research in this area.

In the research conducted by Basarir and Arman (2014), the focus was on examining the effects of economic growth on the environment. Employing the Auto Regressive Distributed Lag (ARDL) method, the researchers investigated the relationship between income per capita and environmental degradation over the period from 1970 to 2010. Their findings revealed a positive association between income per capita and environmental deterioration, indicating that as income levels increased, environmental degradation also intensified. Interestingly, the study did not find evidence of environmental degradation during the specified time period, suggesting that other factors might have mitigated the potential negative impacts of economic growth on the environment. Furthermore, the researchers included variables such as trade openness ratio, energy consumption, and the Human Development Index (HDI) as explanatory factors in their analysis. They found that all three variables exhibited negative associations with CO2 emissions, indicating that higher levels of trade openness, energy consumption, and human development were associated with lower CO2 emissions.

Saboori et al. (2012) conducted an empirical analysis aimed at exploring the Environmental Kuznets Curve (EKC) in Indonesia, focusing on the role of energy consumption and foreign trade. The study examined historical data from Indonesia spanning from 1971 to 2007, incorporating variables such as real Gross Domestic Product (GDP), trade openness ratio, and energy consumption. Utilizing the Auto Regressive Distributed Lag (ARDL) technique, the researchers investigated the existence of an Environmental Kuznets Curve in Indonesia. Their analysis revealed significant evidence supporting the presence of an EKC, as depicted on the graph. This suggests that as the Indonesian economy progressed over time, there was an observable pattern where environmental degradation initially increased but eventually declined as certain economic thresholds were reached. By considering the role of energy consumption and foreign trade alongside economic growth, Saboori et al. provided valuable insights into the environmental dynamics of Indonesia. Their findings contribute to the broader understanding of the relationship between economic development, energy usage, trade, and environmental sustainability in the context of a developing country like Indonesia.

Wagner (2015) delved into a common issue pervasive in environmental economics literature regarding the econometric weakness of Environmental Kuznets Curve (EKC) studies. Many researchers often overlooked the statistical properties of their data, leading to unreliable findings regarding the existence of the EKC phenomenon. Through his study, Wagner aimed to address this concern by advocating for the use of appropriate statistical techniques. By applying robust methods that account for the integrated nature of the underlying processes, Wagner demonstrated that the evidence supporting the Environmental Kuznets Curve weakened significantly. The researcher highlighted that the conventional approach neglects the fact that the powers of integrated processes themselves are not integrated processes. Therefore, the existence of the environmental Kuznets curve becomes less apparent when more suitable techniques, such as co-integration analysis, are employed. Wagner's findings underscored the importance of rigorous statistical methods in environmental economics research, particularly when investigating complex relationships like the EKC. By utilizing appropriate techniques, researchers can ensure more reliable and accurate assessments of environmental phenomena and their economic drivers.

Dinda (2004) conducted a comprehensive review of both theoretical frameworks and empirical studies concerning the Environmental Kuznets Curve (EKC). The author concluded that while some pollutants exhibit an inverted "U" shaped relationship with income, this pattern is mainly observed for local and air pollutants. In defining the EKC, Dinda outlined three distinct stages: an initial increase in pollution, followed by a period of stabilization, and ultimately a decrease in pollution levels. This trajectory reflects the transition of economies from agrarian to industrialized, and eventually towards service-based economies. One of the key insights from Dinda's review is the lack of consensus regarding the income level at which the EKC begins to decline. This ambiguity underscores the need for more accurate econometric models that can capture the complex relationship between economic growth and environmental degradation. Furthermore, Dinda emphasized the importance of identifying the dominant factors influencing environmental degradation, as well as the estimation of structural models rather than relying solely on reduced-form models. Additionally, the author advocated for decomposition analysis and time series techniques to better understand the dynamics of the EKC. Moreover, Dinda highlighted the necessity for bold policy measures at both the political and societal levels. Such measures should promote the adoption of new technologies that mitigate pollution while raising public awareness about environmental issues.

Grossman and Krueger (1994) conducted a notable study estimating the Environmental Kuznets Curve (EKC) for three different pollutants: sulfur dioxide (SO_2), fine smoke, and suspended particles (SPM). Their research focused on assessing the impact of the North American Free Trade Agreement (NAFTA) on atmospheric pollution levels in Mexico. The study utilized data from the World Health Organization, obtained through the Global Environmental Monitoring System (GEMS), covering the period from 1977 to 1988. Additionally, data on real Gross Domestic Product (GDP) for Mexico was sourced from Summer and Heston (1991). Using regression analysis with cubic functions, Grossman and Krueger explored the relationship between economic growth, trade agreements, and environmental pollution. They found that the levels of pollutants gradually increased for all three variables initially, but after reaching a certain turning point, environmental quality began to improve. This finding suggested the presence of an Environmental Kuznets Curve, where economic development initially leads to higher pollution levels, but at higher levels of income, environmental quality improves. The study provided valuable insights into the complex interplay between trade agreements, economic growth, and environmental outcomes, particularly in the context of developing countries like Mexico.

Panayotou (1993) conducted a comprehensive study estimating Environmental Kuznets Curves (EKC) for various pollutants and deforestation across multiple countries. The study encompassed four key pollutants: sulfur dioxide (SO_2), nitrogen oxides (NOX), suspended particulate matter (SPM), and deforestation. Pollution indicators were measured in a similar manner to previous research efforts, particularly following the methodology outlined by Seldon and Song (1994). However, the measurement of deforestation differed, with Panayotou using the mean value of deforestation rates in the mid-1980s. Some social scientists criticized this approach, arguing that it may have biased the measurement by neglecting afforestation activities occurring during the data period. Panayotou employed a logarithmic quadratic function for income in the regression equations for the three pollutants, while managing a translog function for deforestation. Additionally, dummy variables were introduced to account for tropical countries' unique characteristics. The study found that all resulting curves exhibited the characteristic shape of Environmental Kuznets Curves, indicating an initial increase in pollution levels followed by a subsequent decline after reaching a certain income threshold. While the turning points varied across pollutants and countries, they generally fell within a similar range observed in previous research efforts. Overall, Panayotou's study contributed valuable insights into the relationship between economic development and environmental degradation on a global scale.

Cropper and Griffiths (1994) conducted an extensive study to estimate Environmental Kuznets Curves (EKC) for three regions: Africa, Latin America, and Asia. The research utilized cross-section pooled time series data spanning from 1961 to 1991, encompassing 64 countries in total. In the estimation process, the researchers included several explanatory variables, such as GDP, time trend, GDP square, rural population density, and dummy variables to capture region-specific effects. The results of the study revealed some interesting insights. In the regions of Africa and Latin America, the time trend and population growth rate were found to be insignificant. However, they were significantly different from zero in Asia. Interestingly, all coefficients in the Asian region were deemed insignificant. This led the authors to conclude that economic growth alone was unable to resolve the issue of deforestation in any of the studied regions. Cropper and Griffiths' research shed light on the complex relationship between economic development and environmental degradation across different geographical regions, highlighting the limitations of relying solely on GDP growth to address environmental challenges such as deforestation.

4. DATA AND METHODOLOGY

In this section, we will delve into the sources of data used in the study and the traditional methodologies employed. Additionally, we will discuss the expected relationships among the variables under examination. Co-integration techniques and the significance of Auto Regressive Distributed Lag (ARDL) method will also be addressed. Following that, we will explore the formulation of long-run and short-run equations, along with the error correction model to quantify shocks in the short run. This discussion will provide insights into how the study captures both the long-term equilibrium relationships and short-term dynamics within the dataset.

In the 1990s, co-integration posed significant challenges for researchers. Pioneering works by Engle and Granger (1987), Johansen (1988, 1991), and Pesaran et al. (1999) laid the groundwork for addressing these challenges. Single equation methods such as Fully Modified OLS or Dynamic OLS required all variables to be integrated of order 1 (I(1)). However, the Auto Regressive Distributed Lag (ARDL) approach, developed by Pesaran and Shin (1998) and Pesaran et al. (1999), offered a more flexible alternative. Unlike other methods, ARDL could be applied regardless of whether the time series were stationary at first difference or at the level.

Engle and Granger's (1987) and Johansen's (1988, 1991) methods were primarily used for bivariate analysis. On the other hand, both ARDL and Johansen's co-integration technique necessitated a pre-test for unit root. Johansen's approach was specifically designed for time series that were stationary at first difference. These methodologies represented significant advancements in econometric techniques during the 1990s, enabling researchers to more effectively analyze co-integrated time series data and understand the relationships between variables in economic and financial contexts.

5. RESULTS AND DISCUSSION

In this part, statistical measures such as the mean, median, standard deviation, skewness, and kurtosis will be calculated and discussed for the selected variables. These measures provide insights into the central tendency, dispersion, and shape of the data distribution.

Table 1: Descriptive Statistics

Descriptive statistics	Co2p	GDP Per capita	Trade openness	Number of vehicles	Services sector output
Mean	0.000634	28083	0.335300	3996684	2294428
Median	0.000648	11077	0.334499	3351300	599228
Maximum	0.000969	137209	0.389095	15168100	12901802
Minimum	0.000303	864	0.277198	426153.0	20608
Std. Dev.	0.000216	36371	0.028554	3439732	3440758
Skewness	-0.016875	1.62058	-0.182718	1.555083	1.771123
Kurtosis	1.709550	4.650764	2.480214	5.346771	5.039637

Table 1 presents descriptive statistics for five variables: Co2p (CO_2 emissions per unit of production), GDP per capita, Trade openness, Number of vehicles, and Services sector output. These statistics offer insights into the central tendency, dispersion, and shape of the distribution for each variable. The mean values provide an indication of the average level of each variable across the dataset. For instance, the mean Co2p value is approximately 0.000634, suggesting the average CO_2 emissions per unit of production observed in the dataset. Similarly, the mean GDP per capita is 28083, representing the average GDP per person across the observations. Median values serve as measures of central tendency that are less influenced by extreme values compared to means. For example, the median GDP per capita is 11077, indicating that half of the observations have GDP per capita values below this threshold. This provides a more robust measure of the typical value of GDP per capita. Maximum and minimum values denote the highest and lowest observed values in the dataset, respectively. For instance, the maximum Trade openness value is 0.389095, representing the highest level of trade openness observed, while the minimum Number of vehicles value is 426153.0, indicating the lowest number of vehicles observed in the dataset. The standard deviation quantifies the dispersion or variability of data points around the mean. A higher standard deviation suggests greater variability. For example, the standard deviation of GDP per capita is 36371, indicating considerable variability in GDP per capita across the observations. Skewness measures the asymmetry of the distribution. Positive skewness suggests a right-skewed distribution (tail extends more to the right), while negative skewness indicates a left-skewed distribution (tail extends more to the left). For example, the Services sector output variable has a skewness of 1.771123, indicating a right-skewed distribution. Kurtosis measures the peakedness or flatness of the distribution. Higher kurtosis values indicate a more peaked distribution, while lower values indicate a flatter distribution compared to a normal distribution. For example, the kurtosis of GDP per capita is 4.650764, suggesting a relatively peaked distribution compared to a normal distribution with a kurtosis of 3. These descriptive statistics offer valuable insights into the characteristics of the variables, aiding in understanding their typical values, variability, and distributional shape. They are essential for identifying potential outliers, assessing the need for data transformation, and selecting appropriate statistical techniques for further analysis.

In Table 2, unit root tests are conducted on various variables to assess their stationarity over time, which is essential for time series analysis. Each variable undergoes three different specifications: Level, Trend, and 1st Difference (1st Diff), each capturing different aspects of the data's behavior. For the variable Lco2p, the Level specification with an Intercept yields a test statistic of -2.625606, indicating stationarity, while the Trend specification suggests stationarity with trend, evidenced by a test statistic of -3.77000. Similarly, the 1st Difference specification indicates stationarity with a first difference, with a test statistic of -2.624057. The variable Log of GDP Per Capita exhibits similar patterns. Both the Level and Trend specifications indicate stationarity, with test statistics of -2.625606 and -3.77000, respectively. Additionally, the 1st Difference specification implies stationarity with a first difference, yielding a test statistic of -2.622585. Likewise, the Log of GDP Per Capita Square variable demonstrates stationarity across all specifications, with test statistics consistent with those of Lco2p and the Log of GDP Per Capita. However, the Log of Trade Openness variable exhibits slightly different behavior. While the Level specification suggests stationarity with a test statistic of -1.948886, the 1st Difference specification indicates stationarity with a first difference, with a test statistic of -1.949097. For the Log of Number of Vehicles variable, both the Level and Trend specifications suggest stationarity, with test statistics of -2.622585 and -3.770000, respectively. The 1st Difference specification also indicates stationarity with a first difference, yielding a test statistic consistent with the Level specification. Lastly, the Log of Services Sector Output variable shows similar patterns to the Log of GDP Per Capita and Lco2p variables, with stationarity indicated across all specifications. Overall, these unit root tests provide insights into the stationarity of the variables under consideration, aiding in the selection of appropriate data transformations and ensuring the validity of time series models applied to the data.

Table 2: Estimated Outcomes

Variable	Test for Unit Root in	Include in test equation	Test statistics	DF-GLS test statistic	Results
Lco_2p	Level	Intercept	-2.625606	-0.183969	1(1)
		Trend	-3.770000	-0.7827	
	1st Diff	Intercept	-2.624057	-3.412853	
Log of GDP Per Capita	Level	Intercept	-2.625606	1.3297	1(1)
		Trend	-3.77000	-2.047810	
	1st Diff	Intercept	-2.622585	-4.563273	
Log of GDP Per Capita Square	Level	Intercept	-2.625606	1.329712	1(1)
		Trend	-3.77000	-2.047810	
	1st Diff	Intercept	-2.6225	-4.6547	
Log of Trade Openness	Level	Intercept	-1.948886	-2.466142	1(0)
Log of Number of Vehicles	Level	Intercept	-2.622585	0.222476	1(1)
		Trend	-3.770000	-2.199408	
	1st Diff	Intercept	-1.949097	-2.5268	
Log of Services Sector Output	Level	Intercept	-2.625606	1.137656	1(1)
		Trend	-3.77000	-2.2604168	
	1st Diff	Intercept	-2.622585	-4.489725	

Table 3 provides detailed coefficients, standard errors, t-statistics, and probabilities for both the long-run and short-run results of a regression analysis. This analysis likely aims to examine the relationships between several variables and the dependent variable LCO2P, which represents the logarithm of CO2 emissions per unit of production, over time. In the long-run results, the coefficient for LGPC (Log of GDP per Capita) is 15.92, indicating that a one-unit increase in the log of GDP per capita corresponds to a 15.92 unit increase in LCO2P in the long run. This coefficient is statistically significant at the 1% level, suggesting a strong positive relationship between GDP per capita and CO2 emissions. The coefficient for LGPCSQ (Square of Log of GDP per Capita) is -8.48, indicating a negative relationship between the square of log GDP per capita and LCO2P. It is also statistically significant at the 1% level, suggesting a non-linear relationship between GDP per capita and CO2 emissions. Regarding other variables, LNV (Log of Number of Vehicles) shows a coefficient of 0.08, implying a positive relationship with LCO2P, though statistically significant only at the 5% level. LSER (Log of Services Sector Output) and LTO (Log of Trade Openness) exhibit coefficients of 0.946 and 0.94, respectively, indicating positive relationships with LCO2P and high statistical significance. The constant term in the regression equation, represented by the CONSTANT coefficient of -24.309, signifies the baseline level of LCO2P when all independent variables are zero. It is highly statistically significant, indicating its importance in the model. In the short-run results, changes in variables from their lagged values are examined. For instance, D(LGPC) and D(LGPCSQ) represent changes in the log of GDP per capita and its square, respectively. These changes are also statistically significant, suggesting their relevance in explaining short-term fluctuations in LCO2P. Furthermore, the results include coefficients for lagged variables and a cointegration equation. The ARDL bound test provides additional insights into the cointegration relationship among the variables, aiding in understanding their long-term dynamics. Overall, these results provide valuable insights into the relationships between the variables and LCO2P, shedding light on potential drivers of CO2 emissions per unit of production over time.

Table 3

Variable	Coefficients	Standard Error	t-statistics	Probability
		Long run coefficient		
LGPC	15.92	5.39	2.95	0.0036
LGPCSQ	-8.48	2.69	-3.14	0.0039
LNV	0.08	0.036	2.42	0.021
LSER	0.946	0.16	6.14	0.00
LTO	0.94	0.16	5.89	0.00
CONSTANT	-24.309	2.29	-10.61	0.00
Co integrating Form	LCO2P - (15.9209 LGPC -8.4844 LGPCSQ+0.0888 IINV+ 0.9532 LSER + 0.9462 LTO -24.3092)			
SHORT RUN RESULTS				
D (LCO2P (-1))	-0.24	0.12	-1.91	0.06
D(LGPC)	14.23	4.56	3.120	0.0042
D (LGPCSQ)	-7.19	2.2662	-3.1763	0.0036
D(LTO)	0.5717	0.15	3.77	0.0008
D (LNV)	0.096	0.13	0.74	0.4642
D (LNV (-1))	-0.44	0.15	-2.835	0.00830
D(LSER)	0.29	0.21	1.35	0.18
CointEQ (-1)	-0.89	0.14	-6.09	0.0000
ARDL bound test				
F statistics	6.50	Significance	I (0) BOUND	I (1) BOUND
		1%	3.41	4.68

6. CONCLUSIONS

The perspective of "grow now, clean up later" has indeed become a common approach in many developing countries, where economic development is prioritized over environmental concerns. Unfortunately, this approach has often led to prolonged environmental degradation, particularly in the case of least developed countries (LDCs), which have struggled to reach the turning point of the Environmental Kuznets Curve (ECK) for decades. The true nature of the income-environment relationship is often depicted as monotonic, meaning that environmental degradation initially worsens with economic growth before eventually improving. However, the curve takes time to slope downward, indicating that the environmental benefits of economic growth may not be immediately apparent. In the conceptual and theoretical background of the study, it is essential to discuss the economic rationale behind this phenomenon and explore the links among various indicators of environmental degradation. This may involve examining factors such as industrialization, urbanization, energy consumption patterns, technological advancements, regulatory frameworks, and international trade dynamics. By understanding these economic reasons and interconnections, researchers can gain insights into the complex relationship between economic growth and environmental degradation. This knowledge is crucial for formulating effective policies and strategies aimed at achieving sustainable development goals while mitigating environmental risks and preserving natural resources for future generations.

In developing countries, several factors contribute to environmental degradation, including the scale effect, pollution haven hypothesis, and displacement hypothesis, all of which play a role in the accumulation of CO2 in the atmosphere. Grossman and Kruger (1992) were among the first researchers to discover the Environmental Kuznets Curve (EKC), which suggests an inverted U-shaped relationship between economic development and environmental degradation.

Subsequent studies by researchers such as Cole and Neumayer (2004), Ahmed and Long (2012), Shahbaz et al. (2013), Ismail et al. (2014), Fan and Zheng (2013), Saboori et al. (2012), and Wagner (2015), among others, have also investigated the EKC phenomenon. While many of these studies support the existence of the EKC, some have raised questions about the validity of previous research findings. In short, the body of research on the EKC provides valuable insights into the complex relationship between economic growth and environmental quality. However, ongoing debate and scrutiny are essential to refine our understanding of this relationship and develop effective policies to promote sustainable development while mitigating environmental degradation. The time series data for Pakistan's economy from 1972 to 2014 was collected from official sources such as the State Bank of Pakistan (SBP) and the World Bank. Stationarity of the data was tested using the Dickey-Fuller test, and the Auto Regressive Distributed Lag (ARDL) technique developed by Pesaran et al. (1999) was employed to examine the existence of the Environmental Kuznets Curve (EKC).

The findings of the study align with Grossman and Krueger (1992), suggesting that CO2 emissions initially increase but then decrease with an increase in income per capita. This supports the notion of an inverted U-shaped relationship between economic development and environmental degradation, as proposed by the EKC hypothesis. The confirmation of the Environmental Kuznets Curve (EKC) in Pakistan implies that as the economy progresses and income per capita increases, there's a notable improvement in environmental conditions after a certain threshold is reached. This finding underscores the importance of sustainable development policies that aim to boost economic growth while simultaneously mitigating environmental degradation. Additionally, it highlights the need for targeted interventions to address the challenges posed by trade openness, ensuring that economic expansion does not come at the expense of environmental sustainability. Furthermore, the study's use of time series data spanning several decades provides a robust foundation for its conclusions, offering insights into the long-term dynamics of economic growth and environmental quality in Pakistan. By employing advanced econometric techniques like the Auto Regressive Distributed Lag (ARDL) model, the study not only confirms the existence of the EKC but also sheds light on the specific mechanisms at play within the Pakistani context. Overall, the findings contribute to the ongoing discourse on the relationship between economic development and environmental conservation, providing valuable insights for policymakers, researchers, and practitioners alike. They underscore the importance of adopting holistic approaches to development that prioritize both economic prosperity and environmental sustainability, ensuring a balanced and resilient path to progress.

REFERENCES

Ahmed and Long (2012). Environmental Kuznets curve and Pakistan: An empirical analysis. *Procidia economic and finance*. 4-13.

Andreoni and Levinson(2001). The simple analytics of the Environmental Kuznets Curve. *Journal of Public Economics*, 80(2), 269– 286.

Antweiler, C. and Taylor, (2001). Is free trade good for the environment? *American Economic Review*. 91(4), 877–908.

Arrow, B. and Costanza, (1995). Economic growth, carrying capacity, and the environment. *Science*. 15, 91– 95.

Basarirand, A. (2014). The effects of economic growth on environments: An application of environmental Kuznets curve in United Arab Emirates. *Journal of science and technology*, 4(1), 53-59.

Beckerman(1992). Economic growth and the environment: whose growth? Whose environment? *World Development*. 20, 481–496.

Birdsall and Wheeler (1993). Trade policy and industrial pollution in Latin America: where are the pollution havens? *Journal of Environment and Development*, 2. 137–149.

Carson, J. and McCubbin, (1997). The relationship between air pollution emissions and income: US data. *Environment and Development Economics*, 2. 433– 450.

Chaudhuri and Pfaff (1998). Household income, fuel choice, and indoor air quality: micro foundations of an Environmental Kuznets Curve. Economics Department, Columbia University. Mimeo.

Cole, R. and Bates, (1997). The environmental Kuznets curve: An empirical analysis. *Environmental and development economic*, 2(4), 401-416.

Cropper and Griffiths (1994). The interaction of populations, growth and environmental quality. *American Economic Review*. 84, 250– 254.

Dinda and Coondoo (2006). Income and emission: a panel data-based cointegration analysis. *Ecological Economics*, 57. 167–181.

Dinda, (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological economic*. 44, 431-455.

Dinda, (2005). A theoretical basis for the environmental Kuznets curve. *Ecological economic*. 53, 403-413.

Ezzati, S. and Kammen (2001). Towards an integrated framework for development and environmental policy: the dynamics of Environmental Kuznets Curves. *World Development*. 29(8). 1421–1434.

Fan and Zheng, (2013). An empirical study of the environmental Kuznets curve in Sichuan province, China. *Science and eduction*, 2(3), 107-115.

Figueroa, B. and Pastenc, (2009). Country specific environmental Kuznets curves: A random coefficient approach applied to high-income countries. *Estudios de economic*, 36(N), 5-32.
Grossman and Krueger(1993). Environmental impacts of the North American Free Trade Agreement. In: Garber, P. (Ed.), The U.S. –Mexico Free Trade Agreement. MIT Press. Cambridge,13–56.
Harbough, T. Levinson and Wilson (2002). Reexamining the empirical evidence for an environmental Kuznets curve. *Economic and statistics*, 84(3), 541-551.
He, and Richord, (2009). Environmental Kuznets curve for co2 in Canada. Group de recherché and economics. *Developments International*, 01-25.
Inda, S. (2002). A theoretical basis for Environmental Kuznets Curve. Economic Research Unit, Indian Statistical Institute, Kolkata. Mimeo.
Jalil and Mahmud (2009). Environment Kuznets curve for CO2 emissions: A cointegration analysis for China. *Energy Policy*. *37*(12), 5167-5172.
Levinson. (1996). Environmental regulations and manufacturers' location choices: evidence from the census of manufactures. *Journal of Public Economics*. 62, 5– 29.
Li, D. L. and Yang, (2004). Is there an inverted u-shaped curve? Empirical analysis of the environmental Kuznets curve in a grochemicals. *Sci Eng*, 1-12.
Liddle (2001). Free trade and the environment – development system. *Ecological Economics*. 39(1), 21– 36.
Magnani, (2000). The Environmental Kuznets Curve, environmental policy and income distribution. *Ecological Economics*. 32, 431–443.
Panayotou. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development, ILO, Technology and Employment Programme, Geneva.
Perman and Stern (2003). Evidence from panel unit root and cointegration tests that the environmental Kuznents curve does not exist. *Australian Journal of Agricultural and Resource Economics.* 47, 325–347.
Rees (1990). Natural Resources: Allocation, Economics and Policy (2nd edn.). London: Routledge and Kegan Paul.
Selden and Song (1994). Environmental quality and development: is there a Kuznets Curve for air pollution emissions? *Journal of Environmental Economics and management*. 27, 147– 162.
Shafik and Bandyopadhyay (1992). Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence. Background Paper for the World Development Report. The World Bank, Washington, DC.
Stern (2004). The Rise and Fall of the Environmental Kuznets Curve. *World Development*, 32(8), 1419-1439.
Stern (2006). Reversal of the trend in global anthropogenic sulfur emissions. *Global Environmental Change.* 16. 207–220.
Stern, (2004). Environmental Kuznets curve. *Encyclopedia of energy*. 2, 517-525.
Stern, (2004). The Rise and fall of the environmental Kuznets curve. *World development*, 33(8), 1419-1439.
Stern, S. (2003). International society for ecological economic internet encyclopedia of ecological economic. The environmental Kuznets curve. Rensselaer polytechnic institute. Troy NY 12180.
Stern, S. C. and Babier, B. (1996). Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development. *World development*, 24(7), 1151-1160.
Sulaiman, and Mohd, (2012). An empirical analysis of the environmental Kuznets curve for co2 emission in Indonesia: The role of energy consumption and foreign trade. *International journal of economic and finance.* 4(2), 243-251.
Vukina, B. and Solakoglu (1999). Transition to markets and the environment: effects of the change in the composition of manufacturing output. *Environment and Development Economics*. 4(4), 582– 598.
Wagner, (2015). The environmental Kuznets curve, co-integration and nonlinearity. *Applied econometric*, 3, 948-967.
Yaduma, K. and Wossink, (2013). The environmental Kuznets curve at different levels of economic developments: A counterfactual quantile regression analysis for co2 emission. Economic discussion paper series EDP 1322. 1-37.
Yandle, B. and Vijayaraghavan, 2004. Environmental Kuznets curves: A review of findings, methods and policy implication. *Research study*, 2(1), 01-38.
Yandly, V. and Bhattarai, (2002). The environmental Kuznets curve, a primer. *Research study*, 2(1), 1-24.