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Impact Of Human Development And Economic Growth On Environmental Quality

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Abstract

This study makes a valuable contribution to the existing literature by examining the impact of economic growth and human development on environmental quality using two different Environmental Kuznets Curve (EKC) specifications. The analysis focuses on 32 Mediterranean countries from 1990 to 2019 and considers two distinct subpanels: developed and developing countries. By employing advanced panel unit root and cointegration tests that account for cross-sectional dependence, the study finds that the relationship between per capita income and environmental degradation follows an inverted U-shaped pattern, supporting the traditional EKC hypothesis. Conversely, when examining the relationship between human development and environmental degradation using a modified EKC (MEKC) framework, a similar inverted U-shaped relationship is observed. These findings suggest that economic growth and human development contribute to improving environmental quality primarily in developed countries. Additionally, the study identifies that financial development and trade liberalization in developed countries play a role in environmental improvement.

Keywords: Human development; Economic growth; Environmental quality; Panel Cointegration.

1. Introduction

Climate change has emerged as a global threat with alarming implications for human well-being and economic development. Environmental degradation has become a pressing concern worldwide, as evidenced by its widespread occurrence in recent decades. Consequently, there is a growing need to understand the factors driving environmental degradation. Economic growth, which has been a key driver since the industrial revolution, is closely linked to CO_2 emissions. Empirical analysis of the relationship between economic growth and CO_2 emissions has been conducted extensively over the past three decades, primarily to test the validity of the Environmental Kuznets Curve (EKC) hypothesis. Numerous studies have suggested that environmental degradation and economic growth follow an inverted U-shaped relationship, known as the EKC. This relationship has been explored since the 1990s when Grossman and Krueger (1991) and Selden and Song (1994) provided empirical evidence that economic growth initially contributes to environmental degradation, but beyond a certain threshold, it can lead to environmental improvement.

To investigate the existence of the inverted U-shaped relationship, the majority of studies have utilized gross domestic product (GDP) as an economic indicator and CO_2 emissions as a measure of environmental degradation (Apergis and Payne, 2009; Jalil and Mahmud, 2009; Acaravci and Ozturk, 2010; Pao and Tsai, 2011b; Saboori et al., 2012; Ozturk and Acaravci, 2013), with additional studies considering other indicators such as Biological Oxygen Demand emissions (Apergis and Payne, 2010) and Ecological Footprint (Al-mulali et al., 2015). However, some authors have reported findings that challenge the validity of the EKC hypothesis, suggesting an N-shaped relationship where environmental degradation resurfaces at high growth levels (Bruyn et al., 1998; Friedl and Getzner, 2003; Akbostanci et al., 2009; He and Richard, 2010; Arouri et al., 2012; Chandran and Tang, 2013; Ozcan, 2013). Additionally, Ang (2008) observed a positive linkage between economic growth and CO_2 emissions, while Ghosh (2010) found no causality between economic growth and CO_2 emissions in India. On the other hand, Menyah and Wolde-Rufeal (2010) confirmed a feedback effect between the two variables. Chebbi (2010) and Alam et al. (2012) reported a unidirectional causality running from economic growth to CO_2 emissions.

The inconsistencies in empirical findings have prompted researchers to incorporate other variables that influence both economic growth and CO_2 emissions. Many contributions have emphasized the significant role of factors related to energy consumption (Lean and Smyth, 2010; Pao and Tsai, 2011a; Arouri et al., 2012; Saboori and Sulaiman, 2013; Chandran and Tang, 2013; Ozturk and Acaravci, 2013). Financial development is one such factor that can affect CO_2 emissions through various mechanisms. Tamazian et al. (2009) and Jalil and Feridun (2011) found that financial development led to a decrease in CO2 emissions in BRIC countries and China, respectively. However, Zhang (2011) discovered that financial development actually contributes to increased CO_2 emissions, potentially due to attracting foreign direct investment (FDI) that accelerates economic growth and raises carbon emissions. The impact of FDI on environmental quality has been widely studied, but the conclusions have not reached a consensus. Mielnik and Goldemberg (2002) argued that FDI inflows help promote energy efficiency and reduce CO_2 emissions in host countries, whereas Xing and Kolstad

(2002) demonstrated a positive relationship between FDI and pollutant emissions in host countries. Furthermore, several authors have highlighted the significance of trade openness in contributing to environmental degradation (Jalil and Mahmud, 2009; Lee, 2010; Ozturk and Acaravci, 2013; Kohler, 2013; Al-mulali et al., 2015). The rationale behind this is that trade openness strengthens the stability of the domestic financial sector through financial openness, including foreign direct and portfolio investments.

Several researchers have turned their attention to the emerging debates on human development (HD) within the field of environmental economics. Costantini and Monni (2008) and Costantini and Martini (2010) have introduced HD as a factor for sustainable development within the EKC framework. They argue that adopting a human development perspective can provide a sustainable path for economic development without negatively impacting environmental quality. However, this aspect has received less attention compared to the extensive literature on the relationship between economic growth and the environment. Most research indicates that human development has a positive effect on environmental degradation. For instance, Gürlük (2009) concluded that increased investments in education and health lead to the development of valuable human capital that is less pollution-intensive compared to physical capital. Farhani et al. (2014) demonstrated the significance of the EKC hypothesis, HD, and sustainability in formulating effective environmental policies. Uddin (2021) found that a higher share of education in GDP leads to increased literacy rates, which in turn raises awareness among the population and reduces emissions, thereby mitigating environmental pollution.

Under this backdrop, the current study makes s valuable contribution to the existing literature by examining the potential of economic growth and human development to enhance environmental improvement in 32 countries within the Union for the Mediterranean (UFM) region. The analysis covers the period from 1990 to 2019 and utilizes recently developed panel data methods. The study focuses on two distinct groups of countries based on their level of development: developed countries (22 countries) and developing countries (10 countries). The Mediterranean region is currently experiencing significant demographic, social, cultural, economic, and environmental transformations. Pollution is just one of the challenges that threatens the sustainability of the Mediterranean ecosystem. The region's coasts serve as a vital source of resources for the area, a major center for global trade, and also bear the brunt of the negative environmental impacts resulting from these economic activities. The region alone accounts for 6.7% of global emissions, equivalent to over 2 billion tonnes of CO_2. The analysis employs two specifications: the first specification follows the traditional Environmental Kuznets Curve (EKC) literature, including per capita real GDP, squared GDP per capita, modified Human Development Index (MHDI), financial development, trade openness, and energy consumption as determinant variables in the EKC model. The second specification utilizes the Human Development Index (HDI), squared HDI, financial development, trade openness, and energy consumption as independent variables in the modified EKC (MEKC) model.

The remainder of this article is organized as follows: Section 2 provides a brief review of the relevant literature. Section 3 presents an overview of the econometric modeling approach and provides details on the data utilized. Section 4 presents and discusses the empirical results. Finally, Section 5 concludes the chapter by summarizing the findings and offering policy implications.

2. Literature Review

In this section, we aim to provide a comprehensive review of the existing studies that analyze the influence of economic growth and human development on environmental quality. To achieve this, we organize the literature review into two subsections. The first subsection (2.1) examines the impact of economic growth on environmental quality, while the second subsection (2.2) focuses on reviewing studies that have investigated the relationship between human development and environmental quality. We discuss each subsection in detail below.

2.1 Economic Growth and Environment (EKC)

One of the challenges associated with economic development is understanding the impact of increased economic activity on the natural environment. Human activities, which involve the production and consumption of goods, utilize natural resources and generate solid, gaseous, and liquid waste, exerting significant pressure on the environment. As previously mentioned, the empirical literature on the relationship between income growth and the environment has predominantly focused on testing the EKC hypothesis. The pioneering work of Kuznets (1955), which demonstrated an inverted U-shaped relationship between output growth and income inequality, has been subsequently reformulated to examine the inverted U-shaped relationship between growth and the environment. Since the 1990s, this relationship has been extensively studied, following the empirical evidence provided by Grossman and Krueger (1991), who found that income growth initially leads to environmental degradation, but beyond a certain threshold, it contributes to an improvement in environmental conditions. They also identified three major effects exerted by economic development on the environment: a scale effect, a composition effect, and a technical effect. The scale effect arises from the increased requirements of factors of production and higher waste emissions associated with economic growth, which can accelerate environmental degradation if the nature of the activity remains unchanged. The composition effect reflects the evolution of the productive system, which can have positive or negative implications for the environment. In the early stages of development, as the economy transitions from an agricultural and rural economy to an urban and industrial one, there is a tendency for environmental degradation. However, at more advanced stages of development, the economy shifts towards less polluting activities, such as services or the production of goods with lower pollution intensity. This effect captures the change in the nature of economic activity and is crucial for assessing the environmental consequences of growth. Lastly, the technical effect refers to changes in the production techniques. While technology in the early stages of development may contribute to more pollution, technical progress also enhances the environmental efficiency of the production process. The technical effect highlights that economic growth has also facilitated the development of green technologies, which are characterized by less polluting or pollution-control technologies.

Following the seminal study by Grossman and Krueger (1991), numerous studies have been conducted to test the EKC hypothesis. Some notable studies include Shafik and Bandyopadhyay (1992), Grossman and Krueger (1993), Stern et al. (1996), Ekins (1997), Heil and Selden (1999), Managi and Jena (2008), Fodha and Zaghdoud (2010), Ozturk and Acaravci (2010), Saboori et al. (2012), and Shahbaz et al. (2014). However, these studies have produced conflicting results. The findings vary, with some studies demonstrating an inverted U-shaped relationship (Apergis and Payne, 2009; Pao and Tsai, 2011a; Saboori et al., 2012; Tiwari et al., 2013; Omri et al., 2015; Haseeb et al. 2018; Balsalobre-Lorente et al. 2019; Aziz et al. 2020) or even an N-shaped relationship, indicating a reversal of environmental degradation at high levels of growth (Galeotti and Lanza, 1999; Kim et al., 2011; Arouri et al., 2012; Chandran and Tang, 2013; Ozcan, 2013). Other studies have found a linear relationship (Bertinelli and Strobol, 2005; Azomahou et al., 2006; Auffhammer and Carson, 2009; Omri, 2013), while some have found no significant relationship (Richmond and Kaufmann, 2006). One limitation of this body of literature is that it is susceptible to the omitted variable bias problem due to the use of bivariate models (Frahani et al., 2015).

For this reason, some studies have incorporated additional potential determinants of environmental degradation, such as trade openness, to test the pollution-haven hypothesis, as explored by Halicioglu (2009), Nasir and Rehman (2011), and Omri (2013). Urbanization has also been examined as a factor, with studies conducted by Zhang and Cheng (2009), Hossain (2011), Sharma (2011), and Omri et al. (2014). Financial development has been considered as well, with investigations conducted by Ozturk and Acaravci (2013), Shahbaz et al. (2013:2014), and Omri et al. (2015). However, even these multivariate studies yield conflicting results regarding the existence of the EKC. While Ang (2007) found an inverted U-shaped relationship between income growth and environmental degradation in France, and Jalil and Mahmud (2009) observed a similar pattern in China, Nasir and Rehman (2011) identified it in Pakistan, Cowan et al. (2014) observed it in BRICS countries, and Omri et al. (2015) found it in 14 MENA countries, other studies could not establish the same relationship. For instance, Halicioglu (2009) did not find the inverted U-shaped relationship in Turkey, Jaunky (2010) did not observe it in 36 high-income countries, Menyah and Wolde-Rufael (2010) did not identify it in South Africa, Chandran and Tang (2013) did not find it in ASEAN-5 economies, and Cowan et al. (2014) did not observe it in BRICS countries. In a recent study, Aydin et al. (2023) examined the relationship between nanotechnological innovations, renewable energy consumption, economic growth, and ecological footprint in G7 countries using panel cointegration tests with structural breaks spanning from 1990 to 2018. They found that nanotechnology has the potential to reduce environmental degradation by promoting renewable energy consumption and energy efficiency, making it a crucial tool for sustainable development. However, the study also acknowledged that nanoparticle emissions from nanotechnology could have long-term negative effects on human and environmental health, warranting further investigation. The results indicated that the Environmental Kuznets Curve (EKC) hypothesis held true only for the United States, where nanotechnological innovations had a decreasing impact on environmental degradation. In contrast, Italy and the United Kingdom experienced an increasing impact. Additionally, renewable energy consumption was found to enhance environmental quality in Italy, Japan, the United Kingdom, and the United States. Based on these findings, the study suggested that governments should prioritize the development of nanotechnologies with minimal nanoparticle emissions to promote safer energy savings and renewable energy consumption, thereby increasing the effectiveness of sustainable development policies.

2.2. Human Development and Environment

The integration of environmental issues into human development theories and empirical analysis is currently receiving significant attention in the literature. In 1990, the United Nations Development Programme (UNDP) introduced the first Human Development Report, which aimed to provide a more comprehensive understanding of human life by incorporating indicators of life expectancy, educational attainment, and income into a measure of human development (UNDP, 1990). This approach was inspired by the pioneering work of Sen (1977:1985) and his widely recognized concept of human well-being or human development. Sen defined human development as the process of expanding people's choices in a way that enables them to live longer, healthier, and more fulfilling lives.

However, in recent years, considerable attention has been directed towards understanding the interplay between the environment and human development. This shift in focus was reflected in the formulation of the Millennium Development Goals by the United Nations in 2000, which emphasized the integration of human development and the environment as mutually reinforcing components of sustainable development. Costantini and Monni (2008) conducted a study exploring the relationship between human development and sustainability, finding that adopting a human development perspective can pave the way for a sustainable economic development trajectory. They argued that international development policies should prioritize human development as the primary objective, as an increase in human well-being is crucial for achieving sustainability. Similarly, Alam (2012) examined the long-term relationship between environmental degradation and human development in Pakistan, demonstrating that human development can play a constructive and significant role in attaining sustainable development by promoting the adoption of green technologies and protecting the environment. Farhani et al. (2014) analyzed data from 10 Middle Eastern and North African (MENA) countries spanning the period from 1990 to 2010, and their findings indicated a positive impact of human development on environmental degradation. They also confirmed the existence of a quadratic relationship between human development and sustainability. In a similar vein, Uddin (2014) employed Vector Error Correction Mechanism (VECM) techniques to investigate the relationship between education and environmental pollution in Bangladesh. Their research revealed a long-run linear deterministic relationship between environmental pollution and education expenditure. Hence, educational attainment not only fosters awareness among individuals, leading to reduced emissions and environmental pollution, but also contributes to GDP growth and sustainable development. Recently, An et al. (2023) conducted a study focusing on environmental sustainability and human well-being by analyzing the trends related to green technologies, clean energy, and environmental taxes in the top eight advanced economies from 1990 to 2018. The study employed a panel data approach, specifically the cross-sectionally augmented distributed lags (CS-ARDL) technique, to explore the long-run and short-run relationships among these variables. Additionally, the study considered foreign investment as a control variable. The CS-ARDL estimation revealed that green technologies have a positive impact on both environmental sustainability and human well-being by reducing haze pollution and promoting human development. Furthermore, clean energy and environmental taxes were found to contribute to a sustainable environment and human development. On the other hand, foreign investment was identified as a direct source of haze pollution due to increased industrialization and economic activities. The study's recommendations emphasized the importance of promoting green technology and clean energy to achieve long-term benefits for both the environment and human well-being.

3. Econometrical Methodology

This study aims to investigate the impact of economic growth and human development on environmental improvement in 32 countries of the Union for the Mediterranean (UFM). The selection of specific countries and the timeframe for analysis were based on data availability. The study includes two groups of countries: (1) Developed countries, comprising 22 countries (Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom); and (2) Developing countries, consisting of 10 countries (Albania, Algeria, Bulgaria, Egypt, Hungary, Jordan, Lebanon, Morocco, Tunisia, Turkey). To achieve the research objective, an empirical methodology is proposed in two steps. The first step outlines the model specifications and the data utilized (3.1). The second step entails demonstrating the estimation procedures (3.2).

3.1. Model Specifications and Data

Output growth, human development, trade openness, financial development, foreign direct investment, and energy consumption are commonly employed as factors influencing environmental quality. Among these, CO_2 emissions per capita is the frequently used indicator for pollution. The indicator for foreign trade (T) is calculated as the sum of exports and imports divided by the population, representing the volume of trade per capita. Financial development (FD) is measured by the sum of private sector credit and domestic credit provided by the banking sector divided by the population, indicating financial development per capita. Energy consumption (EC) is measured in kilograms of oil equivalent per capita, serving as a measure of energy consumption. The Human Development Index (HDI) is utilized as an indicator of human development (Gürlük, 2009). Table 1 provides a comprehensive description of the variables and their respective data sources utilized in this study.

Table 1 Description of the variables and the data sources.

Variable	Definition	Data Source
CO_2 emissions (C)	Measured in metric tons per capita	Word Bank
GDP (Y)	Measured in per capita US $ (2005).	Word Bank
Energy consumption (E)	Energy use in kg of oil equivalent per capita	Word Bank
Foreign trade (T)	Defined as export plus import divided by population i.e. total volume of trade per capita.	Calculated using data from World Bank
Financial development (FD)	Defined as private sector credit plus domestic credit provided by banking sector divided by population i.e. financial development per capita.	Calculated using data from World Bank
Human development index (HDI)	Human development index, standard UNDP methodology	Calculated using data from World Bank
Modified HDI (MHDI)	The MHDI measures the average achievements in a country in two basic dimensions of human development (Education index and Life expectancy index).	Calculated using data from World Bank

The review of literature leads us to formulate following empirical model:

$$C_{it} = \alpha_1 + \alpha_2 Y_{it} + \alpha_3 HDI_{it} + \alpha_4 FD_{it} + \alpha_5 TR_{it} + \alpha_6 E_{it} + \mu_i \qquad (1)$$

To test the validity of the EKC hypothesis, we specify and estimate the following multiple regression equations:

$$C_{it} = \alpha_1 + \alpha_2 Y_{it} + \alpha_3 Y_{it}^2 + \alpha_4 MHDI_{it} + \alpha_5 FD_{it} + \alpha_6 TR_{it} + \alpha_7 E_{it} + \mu_i \quad (2)$$

$$C_{it} = \beta_1 + \beta_2 HDI_{it} + \beta_3 HDI^2{}_{it} + \beta_4 FD_{it} + \beta_5 TR_{it} + \beta_6 E_{it} + \mu_i \quad (3)$$

The EKC hypothesis suggests that initial levels of income contribute to pollution, but as income further increases, environmental degradation decreases due to increased environmental consciousness and the use of modern technology that generates less pollution. According to the EKC hypothesis, the expected signs of $\partial Y_{it} / \partial C_{it} > 0$ and $\partial Y_{it}^2 / \partial C_{it} < 0$ indicate an inverted U-shaped relationship between carbon emissions and income growth. Several EKC empirical analyses based on CO_2 emissions, such as those conducted by Moomaw and Unruh (1997), Azomahou et al. (2006), Arouri et al. (2012), Saboori et al. (2012), Shahbaz et al. (2012), and others, have found a U-shaped curve. Therefore, this study introduces a squared term of economic growth (Y^2) to confirm the existence of a U-shaped relationship between carbon emissions and economic growth. In an effort to broaden the understanding of the EKC, we also explore the relationship between human development and environmental quality. This is motivated by the observation that in the initial stages of economic growth, human development tends to prioritize economic progress over environmental concerns, but as the economy matures, human development becomes more aligned with improving environmental quality (Costantini and Monni, 2008). This implies that less developed human capital can result in deteriorating environmental quality, while an efficient and developed financial sector may contribute to improving environmental quality.

Methodologically, our study employs the advanced cointegration test proposed by Pedroni (1999, 2004) to examine the existence of two long-run equilibrium relationships. In the first relationship, we consider per capita real GDP, the square of per capita GDP, modified HDI (MHDI), financial development, trade openness, and energy consumption as independent variables in the EKC model, with CO_2 emissions as the dependent variable. In the second long-run relationship, we include HDI, the square of HDI, financial development, trade openness, and energy consumption as independent variables in the MEKC, with CO_2 emissions as the dependent variable. Subsequently, we estimate the two models using the ordinary least squares (OLS) estimator, which is widely used in various studies. However, the fully modified ordinary least squares (FMOLS) estimator has recently gained popularity over the OLS estimator (Farhani et al., 2014).

3.2. Estimation Procedures

In estimating the final versions of Equations (2) and (3) for the EKC and MEKC models, respectively, we employ recently developed panel econometric techniques. These techniques enhance the statistical robustness of our tests by incorporating country-specific heterogeneity and cross-country dependence. Treating panels as independent across heterogeneous countries, as suggested by Banerjee et al. (2004) and others, could potentially distort the results. To estimate our two models as panel cointegration models, we propose a four-step empirical methodology. First, we describe the data used in our study. Second, we analyze cross-sectional dependence and assess the stationarity of the series. Third, we conduct a cointegration test to investigate the long-run dynamics of cross-sectional dependence among countries. Finally, we estimate the long-run relationships among the variables using appropriate panel long-run estimators, such as Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS).

3.2.1 Descriptive Statistics

Table 2 presents the descriptive statistics for all variables utilized in this study, accompanied by relevant discussions. It provides the mean value, standard deviation, minimum, and maximums valus of the different variables for both the sub-panel countries and the global panel. Per capita CO_2 emissions are measured in metric tons, and we observe that developed countries exhibit the highest average CO_2 emissions (8.983), while developing countries have a lower average of 3.295. A similar pattern emerges for per capita GDP, with developed countries boasting higher average GDP per capita compared to developing countries. Notably, high-income countries demonstrate an overall economic output nearly seven times higher than that of developing countries. Moreover, the data reveals a consistent trend for the HDI, a composite measure of life expectancy, education, and per capita income, wherein developed countries achieve higher HDI scores (0.512), while developing countries score 0.492. Additionally, the average level of financial development is highest among developed countries (72.551), while developing countries record an average of 42.847. Similarly, based on the mean trade percentage of GDP, developed countries exhibit greater openness to international trade compared to developing countries. This finding aligns with the existing literature on international trade, which suggests that more advanced countries tend to have higher levels of trade openness. Energy consumption, measured in kilograms of oil equivalent per capita, is significantly higher in developed countries (3819.269). This value is nearly three times greater than that of developing countries. In summary, the summary statistics indicate that developed countries demonstrate higher per capita GDP, achieve higher HDI scores, exhibit greater trade openness, possess more developed financial sectors, and consume greater amounts of energy compared to developing countries.

Table 2. Summary statistics by panel.

Panel	Descriptives statistics	CO_2	Y	HDI	MHDI	FD	TR	E

Developed countries	Mean	8.983	27036.54	0. 512	0.516	72.551	92.094	3819.269
	Std.dev.	3.796	16336.76	0 .301998	0.295	41.594	51.955	1550.179
	Minimum	3.526	2962.131	0	0	1.125	33.970	1475.301
	Maximum	27.431	87772.69	1	1	202.189	348.393	9428.812
Developing countries	Mean	3.295	3781.512	0.479	0.492	42.847	79.423	1217.67
	Std.dev.	1.747	2588.418	0.306	0.304	24.844	31.455	733.37
	Minimum	0.490	867.806	0	0	3.179	30.476	305.465
	Maximum	8.690	11784.63	1	1	91.768	168.313	3237.353
Global panel	Mean	7.205	19769.35	0.502	0.509	63.268	88.134	3006.269
	Std.dev.	4.220	17372.55	0.303	0.298	39.633	46.877	1809.629
	Minimum	0 .490	867.806	0	0	1.125	30.476	305.465
	Maximum	27.431	87772.69	1	1	202.189	348.393	9428.812

3.2.2 Testing for cross-sectional dependence

The sample data were initially examined using the Pesaran (2004) test for cross-sectional dependence (CD) to determine whether cross-sectional dependence or cross-sectional independence was present. This step is crucial before conducting panel unit root tests, as conventional unit root tests may yield weak results with low power when applied to series with cross-sectional dependence. Hence, we employed the cross-sectionally augmented panel unit root test (CIPS), which is one of the second-generation unit root tests developed by Pesaran (2007) specifically for series assumed to have cross-sectional dependence. The cross-sectional dependence (CD) test proposed by Pesaran (2004) utilizes correlation coefficients between the time-series for each country in the panel. The null hypothesis assumes cross-sectional independence, while the alternative hypothesis suggests cross-sectional dependence. The rejection of the null hypothesis confirms the presence of cross-sectional dependence among the countries. The test statistic follows an asymptotic standard normal distribution and is efficient for large samples and short time intervals.

Pesaran's statistics compute:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \tag{4}$$

Where $\hat{\rho}_{ij}$ is the estimate of

$$\rho_{ij} = \rho_{ji} = \frac{\sum_{t=1}^{T}\varepsilon_{it}\varepsilon_{jt}}{\left(\sum_{t=1}^{T}\varepsilon_{it}^2\right)^{1/2}\left(\sum_{t=1}^{T}\varepsilon_{jt}^2\right)^{1/2}}$$

The null hypothesis to be tested as: $\rho_{ij} = \rho_{ji} = corr(\varepsilon_{it}, \varepsilon_{jt}) = 0$ for i ≠ j and the alternative hypothesis to be tested is $\rho_{ij} = \rho_{ji} \neq 0$ for some i ≠ j.

The results of the Pesaran's CD-test for cross-sectional independence are presented in Table 3. Based on the corresponding p-values, we observed a strong rejection of the null hypothesis of cross-sectional independence for all variables, including carbon emissions, Y, HDI, MHDI, financial development, trade openness, and energy consumption. Therefore, we can conclude the existence of cross-sectional dependence among these variables.

3.2.3 Panel Unit Root Test

The first concern in panel unit root tests is whether the cross-sections within the panel are independent of each other. When dealing with a panel exhibiting cross-sectional dependence, first-generation unit root tests often tend to excessively reject the null hypothesis of stationarity. To address this issue, one of the second-generation unit root tests, namely the cross-sectionally augmented IPS (CIPS) unit root test, is employed to assess the stationarity of the series. This test takes into account both heterogeneity and cross-sectional dependence across panels, making it a popular choice among second-generation panel unit root tests. The CIPS test is crucial in determining the order of integration in the series, which is a prerequisite for panel cointegration models. If the variables under investigation are found to be integrated of order one (I(1)), it suggests stationarity at the first difference, indicating possible long-run cointegration among the variables. One of the commonly used tests in this context is the CIPS test introduced by Pesaran (2007), which is a modified version of the IPS test utilizing the average of individual Augmented Dickey-Fuller (CADF) tests.

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \quad (5)$$

The CIPS statistic's distribution is found to be non-standard, even for large N (number of cross-sections). This test accommodates cross-sectional dependence that may arise from a single unobservable common factor. It is applicable to both unbalanced panels and balanced panels where the cross-sections and time dimensions are of similar magnitude. The results of the CIPS test, as presented in Table 3, indicate that all the variables under consideration are non-stationary at their level form, with intercepts, and with both intercepts and trend in each panel. However, at the first difference level, all the variables exhibit stationarity. This implies that the selected series is integrated of first order in each panel of countries.

Table 3 Cross-section dependence (CD) and panel unit root tests for developed and developing countries.

Pesaran (2004) CD test

Variables	Developed countries		Developing countries	
	T-Statistics	P-value	T-Statistics	P-value
C	13.49	(0.000)	5.20	(0.000)
Y	68.88	(0.000)	29.32	(0.000)
HDI	69.71	(0.000)	30.33	(0.000)
MHDI	66.92	(0.000)	29.39	(0.000)
FD	18.79	(0.000)	9.50	(0.000)
T	56.41	(0.000)	14.49	(0.000)
EC	14.10	(0.000)	13.49	(0.000)

CIPS test

Variables	Developed countries		Developing countries	
	Level	**Δ**	**Level**	**Δ**
C	-0.674 (0.250)	-14.551* (0.000)	-1.086 (0.139)	-9.770* (0.000)
Y	0.074 (0.529)	-7.634* (0.000)	-1.249 (0.106)	-7.407* (0.000)
HDI	2.878 (0.998)	-6.278* (0.000)	2.292 (0.989)	-5.674* (0.000)
MHDI	2.130 (0.983)	-7.900* (0.000)	2.845 (0.998)	-5.724* (0.000)
FD	3.993 (1.000)	-4.834* (0.000)	0.463 (0.678)	-5.276* (0.000)
T	0.990 (0.839)	-3.915* (0.000)	-0.699 (0.242)	-6.991* (0.000)
EC	1.042 (0.851)	-14.045* (0.000)	-0.718 (0.237)	-7.780* (0.000)

Notes: Under the null hypothesis of cross-sectional independence, the Pesaran CD statistic is distributed as a two-tailed standard normal. Δ denotes first differences. A constant is included in the Pesaran CIPS test and rejection of the null hypothesis indicates stationarity in at least one country. Values in brackets denote probability values. Significance level: * (1%).

3.2.4 Panel Cointegration Tests

After conducting the Pesaran (2004) CD test and Pesaran (2007) CIPS unit root tests to verify the stationarity of the series in the underlying models, panel cointegration analysis can be performed. In the literature, several panel cointegration tests are suggested, such as the Pedroni (1999, 2004) panel cointegration test and the Kao (1999) panel cointegration test. For this study, we aim to examine the existence of a long-run equilibrium relationship among the variables using the Pedroni (1999, 2004) panel cointegration test. Pedroni proposes seven different statistics to test for cointegration relationships in heterogeneous panels. These tests are adjusted to account for potential biases introduced by endogenous regressors and are categorized into within-dimension and between-dimension statistics. The within-dimension statistics are referred to as panel cointegration statistics, while the between-dimension statistics are termed mean panel cointegration statistics. The Kao (1999) test is based on the residuals and variations of the Dickey and Fuller (1979) and Phillips and Perron (1988) tests.

The results in Table 4 from the Pedroni panel cointegration test reveal that the analyzed variables for the sub-panels of countries exhibit cointegration based on the majority of the test statistics. Additionally, the Kao panel cointegration test follows a similar procedure to the Pedroni test but incorporates cross-homogeneous coefficients on the first-stage regressors. The results from the Kao panel cointegration test, also presented in Table 5, indicate that all series of variables for both developed and developing countries are cointegrated and possess long-run relationships. This finding is supported by substantial evidence to reject the null hypothesis of no cointegration in favor of the alternative hypothesis of cointegration at a significance level of 1%. With the confirmation of cointegration among the variables, the next step involves estimating the long-run coefficients.

Table 4. Cointegration tests results.

I- Pedroni (1999, 2004) panel cointegration results.					
	Developed countries			Developing countries	
	T-stat.	*Probability*		*T-stat.*	*Probability*
Within-dimension			*Within-dimension*		
Panel v-stat	0.335279	(0.368)	Panel v-stat	1.447988**	(0.073)
Panel rho-stat	1.171138	(0.879)	Panel rho-stat	0.591763	(0.723)
Panel ADF-stat	-5.275907*	(0.000)	Panel ADF-stat	-6.528529*	(0.000)
Panel PP-stat	-6.286117*	(0.000)	Panel PP-stat	-5.946075*	(0.000)
Between-dimension			*Between-dimension*		
Group rho-stat	2.799985	(0.997)	Group rho-stat	1.544742	(0.938)
Group ADF-stat	-6.281565*	(0.000)	Group ADF-stat	-8.205213*	(0.000)
Group PP-stat	-5.587044*	(0.000)	Group PP-stat	-4.233621*	(0.000)
II- Kao's test.					
	Developed countries			Developing countries	
	T-statistics	*Prob.*		*T-statistics*	*Prob.*
ADF	-12.95122*	(0.000)	ADF	-5.410667*	(0.000)

Notes: The null hypothesis is that the variables are not cointegrated. Lag length selected based on SIC automatically with a max lag of 2. Lag selection: Automatic 2 lag by SIC with a max lag of 4. P-values are reported in brackets. Significance levels: * (1%), ** (10%), respectively.

3.2.5 Panel FMOLS and DOLS Estimates

After confirming that all variables for the sub-panel countries are cointegrated, the next step is to estimate the long-run coefficient values of the independent variables. This estimation is accomplished using three different models: ordinary least squares (OLS), DOLS, and FMOLS. These estimators offer the advantage of effectively addressing issues related to endogeneity in the regressors and serial correlations in the error terms. Additionally, these estimators possess desirable asymptotic properties. The FMOLS estimator tackles endogeneity and autocorrelation problems by adopting a non-parametric approach. On the other hand, the DOLS estimator addresses these difficulties through a parametric approach, incorporating lags and leads of the explanatory variables. Both estimators aim to mitigate the challenges associated with endogeneity and serial correlation. The results obtained from the FMOLS and DOLS estimators will be presented in the subsequent section, providing valuable insights into the estimated coefficients in the long run.

The panel FMOLS estimator for the coefficient β is defined as:

$$\hat{\beta} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(y_{it}-\bar{y})^2\right)^{-1}\left(\sum_{t=1}^{T}(y_{it}-\bar{y})\right)z_{it}^{*} - T\hat{\eta}_i \tag{6}$$

Where $z_{it}^{*} = (z_{it}-\bar{z}) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta y_{it}$, $\hat{\eta}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0})$ and $\hat{L}_i$ is a lower triangular decomposition of $\hat{\Omega}_i$. The associated t-statistics gives:

$$t_{\hat{\beta}^*} = N^{-1/2}\sum_{i=1}^{N} t_{\hat{\beta}^*,i} \quad \text{Where } t_{\hat{\beta}^*,i} = \left(\hat{\beta}_i^{*} - \beta_0\right)\left[\hat{\Omega}_{11i}^{-1}\sum_{t=1}^{T}(y_{it}-\bar{y})^2\right]^{1/2} \tag{7}$$

The panel DOLS estimator for the coefficient β is defined as:

$$\beta^{\hat{}\,\ddot{}} = \frac{1}{N}\sum_{i=1}^{N} \quad \left[\left(\sum_{t=1}^{T}(Z_{i,t}\,Z_{i,t})\right)^{-1}\left(\sum_{t=1}^{T} Z_{i,t}\,w_{i,t}\right)\right] \tag{8}$$

Where

$Z_{i,t} = \left[X_{i,t} - \bar{x}_i, \Delta X_{i,t-K_i}, \ldots, \Delta X_{i,t+K_i}\right]$ is vector of regressors, and $\tilde{w}_{i,t} = w_{i,t} - \overrightarrow{w_i}$

4. Results and Discussions

4.1 Results for Developed Countries

Table 5 presents the results of panel FMOLS and DOLS estimates for the EKC model (related to Eq. 2) and the MEKC model (related to Eq. 3) for developed countries. The findings reveal an inverted U-shaped relationship between per capita CO_2 emissions and per capita GDP in the EKC model, as well as between CO_2 emissions and Human Development Index (HDI) in the MEKC model. Specifically, Table 5 presents the panel EKC results, where the FMOLS estimation yields coefficients of 0.574, -0.027, -0.127, -0.004, -0.060, and 1.103 for variables Y (real income per capita), Y^2 (squared term of real income per capita), MHDI (Multidimensional Human Development Index), FD (financial development), T (trade openness), and EC (energy consumption), respectively. The results indicate that the linear term of real income per capita has a positive impact on CO_2 emissions, while the squared term of real income per capita has a statistically significant negative effect on CO_2 emissions at a 1% level of significance. This validation of the environmental Kuznets curve suggests that a 1% increase in real income per capita corresponds to a 0.574% increase in CO_2 emissions, while the inverse effect of the squared term indicates the turning point of CO_2 emissions at -0.027. These findings align with previous studies conducted by Ang (2007), Atici (2009), and Kasman and Duman (2015). Additionally, a 1% increase in MHDI leads to a decrease in CO_2 emissions per capita by 0.127%, highlighting the importance of human development in environmental improvement for developed countries, as noted in studies by Gürlük (2009) and Farhani et al. (2013). Moreover, the negative and significant impact of financial development on CO_2 emissions at a 5% level suggests that the financial sector in these countries contributes to environmental improvement by supporting environmentally friendly investment ventures, thereby enhancing the quality of life and preventing environmental degradation. The development of the financial sector can also incentivize firms to adopt advanced and environmentally friendly technologies in their production processes, resulting in reduced pollution. This finding aligns with the idea that a sound and stable financial system can mitigate environmental pollution through the adoption of new technologies. Furthermore, trade openness exhibits an inverse impact on CO_2 emissions, indicating that a 1% increase in international trade corresponds to a 0.060% decline in CO_2 emissions. This implies that foreign trade reduces CO_2 emissions through technological effects in developed countries, as supported by the work of Managi et al. (2008) and Shahbaz et al. (2012). On the other hand, a 1% increase in energy consumption per capita leads to a 1.1% increase in CO_2 emissions per capita, indicating that as production expands, countries consume more energy, exerting pressure on the environment and resulting in higher emissions. This finding is consistent with the findings of Halicioglu (2009), Atici (2009), Yavuz (2014), Kasman and Duman (2015), and Shahbaz et al. (2015).

Table 5 Panel FMOLS and DOLS results for Developed and Developing countries.

Independent Variables	EKC							
	Developed countires				Developing countries			
	FMOLS		DOLS		FMOLS		DOLS	
	Coef.	Prob	Coef.	Prob	Coef.	Prob	Coef.	Prob
Y	0.574*	(0.000)	0.775*	(0.000)	0.384*	(0.000)	0.448*	(0.001)
Y2	-0.027*	(0.000)	-0.035*	(0.001)	-0.142*	(0.325)	-0.125**	(0.254)
MHDI	-0.127*	(0.000)	-0.142*	(0.000)	0.140	(0.658)	0.120	(0.356)
FD	-0.004**	(0.026)	-0.003	(0.622)	0.068*	(0.000)	0.053**	(0.012)

TR	-0.060*	(0.000)	-0.039	(0.193)	0.017	(0.689)	0.016	(0.728)
EC	1.103*	(0.000)	1.009*	(0.000)	0.908*	(0.000)	0.990*	(0.000)
R-squared	0.988		0.983		0.983		0.980	
Adjusted R-squared	0.987		0.982		0.982		0.979	
				MEKC				
HDI	0.146*	(0.000)	0.768*	(0.000)	0.122*	(0.002)	0.139**	(0.048)
HDI^2	-0.094**	(0.014)	-1.722*	(0.000)	-0.028	(0.434)	-0.082	(0.172)
FD	-0.138*	(0.000)	0.440*	(0.000)	0.071*	(0.000)	0.027***	(0.073)
TR	-0.154*	(0.000)	-0.602*	(0.000)	0.003	(0.834)	0.010	(0.737)
EC	0.412*	(0.000)	0.382*	(0.000)	1.118*	(0.000)	1.119*	(0.000)
R-squared	0.958		0.975		0.981		0.995	
Adjusted R-squared	0.9523		0.971		0.980		0.989	

Notes: P-values are reported in parentheses. Significance levels: * (1%), ** (5%) *** and (10%).

The coefficients from the panel DOLS estimation are 0.775, -0.035, -0.142, -0.003, -0.039, and 1.009 for variables Y (real GDP), Y^2 (squared term of real GDP), MHDI (Multidimensional Human Development Index), FD (financial development), T (trade openness), and EC (energy consumption), respectively. These results align with the findings from the FMOLS method, indicating support for an inverted U-shaped relationship between economic growth (measured by real GDP) and CO_2 emissions, considering both linear and non-linear terms. Specifically, a 1% increase in real GDP leads to a 0.775% increase in CO_2 emissions, while the negative sign of the squared GDP term suggests a decrease in emissions at higher income levels. This finding is consistent with Acaravci and Ozturk (2010) and Fosten et al. (2012). Additionally, a 1% increase in MHDI results in a 0.142% decrease in CO_2 emissions per capita, highlighting the importance of education and life expectancy in environmental improvement. This finding aligns with the studies of Gürlük (2009), Farhani et al. (2013), and Ben Youssef et al. (2016). On the other hand, the effect of financial development and trade openness on CO_2 emissions is negative but not statistically significant. This result is in line with Jalil and Mahmud (2009) and Ozturk and Acaravci (2013). Furthermore, a 1% increase in energy consumption per capita leads to a 1.009% increase in CO_2 emissions per capita, which is consistent with the findings of the FMOLS method regarding energy consumption.

Moving on to the panel MEKC presented in Table 5, the coefficients from the panel FMOLS estimation are 0.146, -0.094, -0.138, -0.154, and 0.412 for variables HDI (Human Development Index), HDI^2 (squared term of HDI), FD (financial development), T (trade openness), and EC (energy consumption), respectively. These results indicate an inverted U-shaped relationship between per capita CO_2 emissions and HDI, suggesting that initially, higher levels of human development are associated with high CO_2 emissions, but as development reaches a turning point or threshold level, CO_2 emissions tend to decrease. This finding is consistent with Costantini and Monni (2008).

Regarding the financial development variable, it is found that a 1% increase in financial development leads to a 0.138% decline in CO_2 emissions, which aligns with the results from the EKC model. The negative and significant impact of financial development on CO_2 emissions implies that financial institutions play a role in improving environmental quality by providing credit for environmental protection and raising awareness of the CO_2 problem in financial markets. This finding is supported by studies such as Tamazian and Rao (2010), Jalil and Feridun (2011), and Omri et al. (2015). Similarly, a 1% increase in trade openness results in a decrease of approximately 0.154% in CO_2 emissions per capita, indicating that increased trade openness improves environmental quality in developed countries. The argument put forth in this study is that a higher degree of financial system development and trade openness can reduce CO_2 emissions through an environment that stimulates technological innovations and increased spending on energy conservation R&D, leading to energy efficiency and lower emissions. This idea is supported by studies such as Blanford (2009) and Shahbaz et al. (2011). Finally, a 1% increase in energy consumption per capita leads to a 0.412% increase in CO_2 emissions per capita, highlighting the significant contribution of energy consumption to energy-related pollutants.

4.2 Results for Developing Countries

Table 5 presents the results of panel FMOLS and DOLS estimations for the EKC model in developing countries. The coefficients obtained from the panel FMOLS estimation are as follows: 0.384 for Y (per capita GDP), -0.142 for Y^2 (squared term of GDP), 0.140 for MHDI (Multidimensional Human Development Index), 0.068 for FD (financial development), 0.017 for T (trade openness), and 0.908 for EC (energy consumption). The results show that per capita GDP has a positive and significant effect on CO_2 emissions, while the squared GDP term is negative. However, the squared GDP term is not statistically significant, leading to the rejection of the EKC hypothesis in these developing countries. This finding suggests that the inverted U-shaped relationship between economic growth and environmental degradation only occurs when technologies for energy efficiency, energy saving, and renewable energy are accessible, which might be costly for developing countries. This result is consistent with previous studies such as Arouri et al. (2012), Musolesi et al. (2010), and Jaunky (2011). Regarding the impact of MHDI on carbon emissions, the results indicate that MHDI does not have a significant effect on CO_2 emissions. This implies that in developing countries, the primary focus of policies should be on human development, as increasing human well-being is crucial for creating a sustainable environment. This finding contradicts the result shown by Farhani et al. (2013). Furthermore, the effect of financial development on CO_2 emissions is positive and significant at the 1% level. This suggests that developing countries are not effectively channeling financial development into environmentally friendly and sustainable systems. Financial institutions should take the initiative in protecting the environment, such as offering special loans with lower interest rates for investments in low-carbon-based products. This result is consistent with findings from Zhang (2011), Al-mulali and Sab (2012), and Omri et al. (2015). The results also indicate that trade openness does not have a significant impact on carbon emissions in the long run. This may be due to the imposition of taxes on trade-related gas emissions and other environmental regulations that discourage multinational firms from moving to developing countries. Finally, a 1% increase in energy consumption per capita leads to a 0.9% increase in CO_2 emissions per capita, which is significant. This finding highlights the significant contribution of energy consumption to environmental pollution.

For the DOLS estimation in the EKC model, the coefficients are as follows: 2.048 for Y, -0.125 for Y^2, 0.120 for MHDI, 0.053 for FD, 0.016 for T, and 0.990 for EC. The results do not confirm the existence of an inverted U-shaped relationship between environmental degradation and economic growth in developing countries, as the squared GDP per capita is not statistically significant. This finding aligns with previous studies such as Ozturk and Acaravci (2010a), Wang et al. (2011), and Chandran and Tang (2013). Moreover, the coefficient of MHDI is positive but not significant, which contradicts the findings of Farhani et al. (2013). The effect of financial development on CO_2 emissions is positive and significant at the 5% level, indicating that financial development contributes to environmental degradation by facilitating access to credit for companies whose investment projects are not necessarily environmentally friendly. Trade openness does not have a significant effect on carbon emissions in the long run, and a 1% increase in energy consumption per capita leads to a 0.99% increase in CO_2 emissions, which is significant. Moving on to the MEKC model, the coefficients from the panel FMOLS estimation are 0.122 for HDI, -0.028 for HDI^2, 0.071 for FD, 0.003 for T, and 1.118 for EC. The results show that the coefficient of HDI is positive and statistically significant, while the coefficient of the squared HDI is negative but not significant. This indicates that the inverted U-shaped relationship between human development and environmental degradation is not applicable in developing countries due to their specific characteristics, such as low rates of education and life expectancy. This finding is compatible with the results found by Gürlük (2009) for Morocco and Tunisia. The effect of financial development on CO_2 emissions is positive and significant at the 1% level, suggesting that financial development contributes to environmental degradation as low levels of financial development appear to be the main driver of emissions. This phenomenon indicates that the financial resources provided to the private sector are invested in non-environmentally friendly projects. Trade openness does not have a significant effect on carbon emissions in the long run. Finally, a 1% increase in energy consumption per capita is expected to increase carbon emissions per capita by 1.118%, which is significant at the 1% level.

For the DOLS estimation inthe MEKC model, the coefficients are as follows: 0.139 for HDI, -0.082 for HDI², 0.027 for FD, 0.010 for T, and 1.119 for EC. Similar to the FMOLS results, the inverted U-shaped relationship between human development and environmental degradation is not valid in developing countries. The coefficient of financial development is positive and significant at the 10% level, indicating that financial development contributes to carbon emissions by facilitating access to credit for non-environmentally friendly projects. Trade openness does not have a significant effect on carbon emissions, and an increase in energy consumption leads to a significant increase in CO_2 emissions.

Overall, the study finds that the inverted U-shaped relationships between economic growth-environmental degradation and human development-environmental degradation exist only in developed countries. This suggests that economic growth and human development should be the primary objectives of policies in developing countries, as they are essential for achieving environmental improvement and sustainability.

5. Conclusion and Policy Implications

The aim of this study was to analyze the impact of economic growth and human development on environmental improvement in 32 UFM countries from 1990 to 2019 using panel data methods. The countries were divided into two groups based on their level of development: developed (22 countries) and developing (10 countries). Two specifications were used for the analysis: the traditional EKC model, including variables such as per capita real GDP, squared GDP per capita, modified Human Development Index (MHDI), financial development, trade openness, and energy consumption; and the modified EKC model, using variables, such as HDI, squared HDI, financial development, trade openness, and energy consumption.

The main findings reveal that the linear term of per capita GDP has a positive impact on CO_2 emissions, while the squared GDP term has a negative effect only in developed countries. This supports the inverted U-shaped relationship proposed by the EKC theory, which suggests that pollution levels increase during development and then decrease after reaching a certain income threshold. Additionally, an inverted U-shaped relationship is found between per capita CO_2 emissions and HDI, but only in developed countries. This indicates that human development initially leads to higher CO_2 emissions, but as development reaches a turning point, emissions tend to decrease. The countries with the highest education and life expectancy indices play a significant role in environmental improvement. The effect of financial development on CO_2 emissions is negative in developed countries, implying that the financial sector contributes to environmental improvement by providing loans for environmentally friendly investments. These countries also adopt cleaner technologies for industry after achieving sustainable development. Higher levels of financial development and trade openness promote technological innovations, including increased spending on energy conservation R&D, leading to energy efficiency and lower emissions.

Furthermore, this study provides additional policy implications for developing countries. First, it is crucial to prioritize investment in human development as a means to achieve a sustainable environment. By enhancing health and education, developing countries can improve the well-being of their populations while simultaneously promoting environmental sustainability. Active participation of developed countries and engagement in globalization processes can bring significant benefits, but it is essential for developing countries to have effective mechanisms in place to manage these processes. This includes ensuring that the gains from globalization are channeled towards enhancing human capabilities and fostering sustainable development. Second, developing countries should focus on building an efficient and robust financial sector. A well-functioning financial system can play a vital role in providing capital to investors, facilitating liquidity for economic agents, and effectively allocating capital among different economic sectors. This dynamic can lead to the growth of more dynamic and innovative sectors, thereby reducing reliance on pollution-intensive activities. By supporting the development of cleaner and more sustainable industries, the financial sector can contribute to environmental improvement and promote a higher quality of life for the population. Finally, it is crucial for developing countries to prioritize the implementation of rigorous environmental policies in multilateral investment and trade agreements. International trade has the potential to reduce environmental pollution by promoting the adoption of cleaner production methods and technologies. By incorporating strong environmental provisions into trade agreements, developing countries can ensure that trade is conducted in a manner that is environmentally responsible and sustainable. This includes measures such as promoting sustainable practices, encouraging the use of clean technologies, and enforcing strict environmental standards. In summary, the policy implications of this study emphasize the importance of prioritizing human development, building a strong financial sector, and implementing robust environmental policies in the context of developing countries. By focusing on these areas, developing countries can foster sustainable development, reduce environmental degradation, and enhance the well-being of their populations.

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