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Political Economy of Environmental Poverty: The Role of Political Risk and Income Level

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Abstract

Environmental poverty is a global concern for developed and developing economies, particularly in light of sustainable development goals. Unlike previous research, this study evaluates the role of political risk index and income level on environmental poverty in developed regions, namely, OECD economies in the period 2004–2022. We also examine the role of renewable energy consumption. We initially developed a multidimensional index for assessing weighted average environmental poverty alongside a novel index to gauge political risk within OECD economies. We employ several panel econometric procedures, including cross-sectional dependence and slope heterogeneity, CIPS unit root circle for identifying unit roots and Westerlund cointegration for long-run connection among variables. Besides, the study employed cross-sectional autoregressive distributive lags (CS-ARDL) to identify the short-run and long-run impact of explanatory variables on environmental poverty. The results show that variables are heterogenous and cross-sectionally dependent. Moreover, the unit roots are found within the unit root circle, implying that variables are static at the first difference and long-run equilibrium exists among variables. The empirical results confirm that the political risk index reduces environmental poverty. A one-percent increase in the betterment of the political risk index lowers environmental poverty by −0.022% and −0.034%, respectively. However, the results for *PRI* in the short run are inconclusive while effective

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in the long run. Since the OECD countries have lower political risk and effective *PRI*, economic and financial activities spur, which leads to the positive influence of income on environmental poverty. A one-percent increase in income level (*GDP*) increases environmental poverty in OECD countries by 1.21% and 1.34% in the short and long run. Conversely, the results for renewable energy consumption (*REC*) are negative in both the short and long run and we conclude that *REC* significantly reduces environmental poverty in the region. Besides, the robustness analysis employed through an augmented mean group (AMG) estimator is reported to have similar and robust results. The Dumitrescu–Hurlin panel causality test reports that *REC* and environmental poverty (*ENVP*) have bidirectional causal linkage and provide feedback to each other, while *GDP* and *PRI* have a unidirectional connection and no feedback effect is found. Relevant policies are inferred from the conclusions.

Keywords: Political risk index, GDP, renewable energy consumption, environmental poverty, OECD economies

JEL Classification: E01, P00, Q50, Q40

1. Introduction

Environmental poverty, exacerbated by climate change, environmental degradation and rising greenhouse gas emissions, stands as a critical global challenge. Within the realm of environmental poverty, concerns encompass issues such as energy poverty, access to sanitation and the availability of clean water and air. While developing economies, spanning from underdeveloped to emerging countries, bear the brunt of this predicament, it is crucial to recognize that developed economies, including those within the OECD and G7, are not immune to its adverse impacts. Socioeconomic disparities and the consequences of environmental poverty manifest in developed economies as well, through challenges such as elevated energy costs, insufficient green spaces, compromised air and water quality and deficiencies in sanitation services (Tundys *et al*., 2021). In essence, environmental poverty transcends geographical boundaries, affecting both developing and developed countries, necessitating comprehensive global efforts to address its multifaceted implications.

The global economic forums demonstrated alarming figures, indicating that more than 1.6 billion people have been adversely influenced by environmental poverty, while 2.4 billion people lack access to sanitation services and clean water and 1.6 billion people lack access to energy and fuel technologies (IEA, 2023). With the increasing economic expansion and development, the environmental situation is degrading and not going towards sustainability, which has enforced legal and economic forums to target the challenges created by environmental poverty (Khan, Haouas *et al*., 2023).

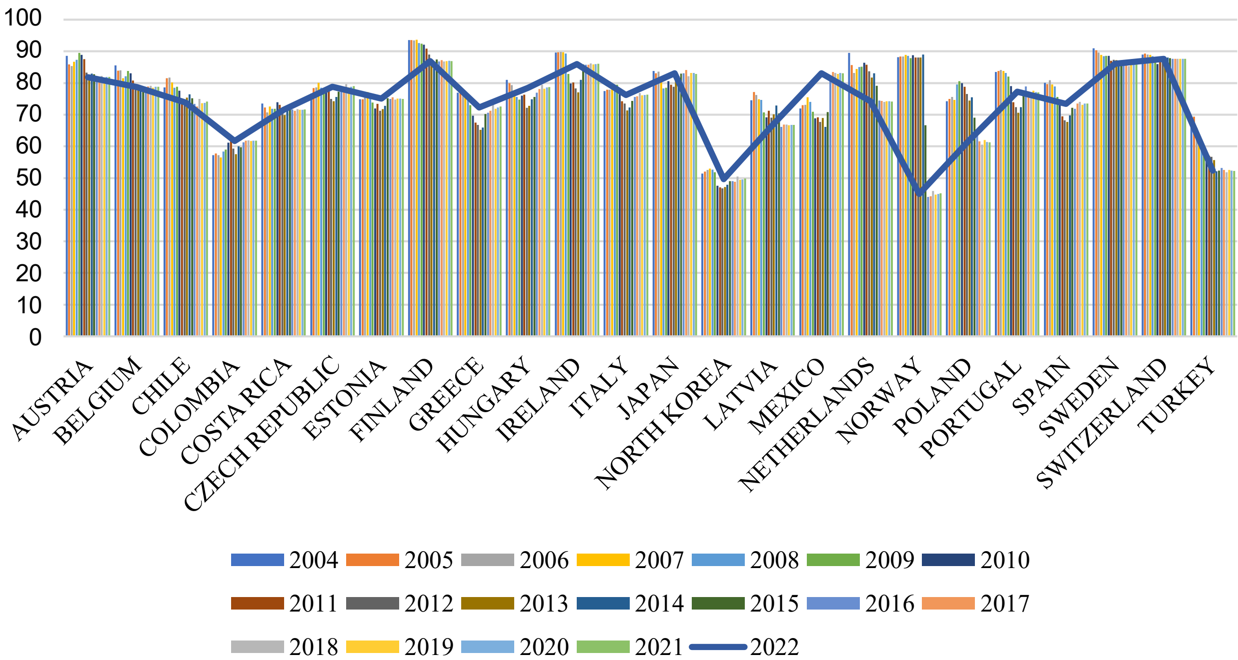
Environmental poverty in its easiest terms can be understood as a lack of facilities and resources needed for sustainable and healthy living practices (Nawaz and Iqbal, 2021). Moreover, the intensity of environmental poverty can also be taken into account for the OECD economies, which despite their developed nature suffer from high energy prices, air and water pollution. In the marginalized areas of these economies, the lack of sanitation services is greater and climatic conditions are harsher, which causes health and socioeconomic problems for the population of these economies (Lee *et al*., 2022). Furthermore, reducing environmental poverty is a combination of sustainable development goals that need to be addressed in this research. More specifically, understanding factors that could alleviate or worsen environmental poverty is essential to achieving the SDGs, since the lessening of environmental poverty is mostly linked to sustainable development and investments in clean energy projects, including achieving energy efficiency measures and improvement of socioeconomic stability in the economies.

Various determinants have been explored ranging from socioeconomic to environmental quality, effective policies and clean sources of energy such as green finance, financial inclusion, renewable energy, green growth and energy efficiency (Essel-Gaisey and Chiang, 2022; Khan, Haouas *et al*., 2023). However, most of the factors related to the stability and institutional quality of countries have been avoided in the previous literature. For instance, political risk leads to weak governance, poor institutional quality and bureaucratic inefficiencies, which can increase instability in economies. Such political unrest increases environmental poverty through direct or indirect channels. The increase in political instability worsens income inequalities in the resources sector, causes the resource curse and depletion of resources, increases corruption and decreases institutional quality, which hinders environmental regulations and boosts environmental degradation and pollution (Z. Wang *et al*., 2023).

Moreover, environmental poverty deepens when the political risk is high in the economy because of the violation of environmental sustainability rules and regulations, more focus on investments for short-term gains from fossil fuel drilling projects and less focus on resource management, which depletes resources and causes unsustainability in terms of prices volatilities and fluctuations (Li *et al*., 2023). Against this backdrop, lower political risk and a stable economy allow more investments in renewable energy projects because of their long-term maturity and the increasing sustainability of the resources due to their efficient management and sustainable extraction, which increases energy efficiency and environmental sustainability. Figure 1 elaborates on the previous statement in a graphical form, where the OECD economies have a stable political risk index in the region. Most importantly, it is observed in the illustration that most of the economies in the panel have higher political risk, such as Austria, Finland, Ireland, Norway, Hungary, Sweden, Switzerland, and the Netherlands.

The level of income is also considered one of the leading factors in environmental sustainability and its influence on environmental poverty. Increasing economic expansion mostly leads to increased air pollution, waste and water depletion along with other resources. The extraction of fossil fuels and the increasing income level leads to increasing consumption and trade, which increases environmental degradation (Qin *et al.*, 2021). Even in developed economies, economic expansion leads to income inequalities, which also leads to unequal distribution of resources; however, the low-income groups not only face income inequality but also the wrath of climatic conditions and climate change. On the other hand, economies with sustainable extraction of resources, investing revenues in climate control technologies, construction of renewable energy infrastructure and reduction of air and water pollution can lead to increased environmental quality (Khan, Badeeb *et al.*, 2023).

Figure 1: Overview of political risk of OECD economies



Source: ICRG (2023)

Against this backdrop, we intend to examine the role of political risk and income level on environmental poverty in OECD economies in the period 2004–2022. This study also observes the role of renewable energy consumption and its employment of CS-ARDL as the main estimation technique along with other panel tests necessary to empirically explain the research.

Moreover, we design an environmental poverty index from various components of environmental poverty. The environmental poverty index construction varies from the previous research, which constitutes the literature gap of the study and the scope of the research, which differentiates it from the previous studies.

This research makes a threefold contribution. As far as we are aware, this is the first study to investigate the role of the political risk index and income on the environmental poverty index with additional observations of renewable energy consumption. Secondly, from what we have observed, this research proposes a new methodology for the environmental poverty index that has not been widely implemented in previous research. Thirdly, this research encompasses a consistent period of panel data spanning from 2004 to 2022 for OECD economies and employs CS-ARDL as the main estimator along with other panel methods, which include CIPS unit root and Westerlund cointegration, to determine unit roots and long-run equilibrium among variables. Moreover, the research also includes an augmented mean group (AMG) estimator for robustness procedure, while the Dumitrescu-Hurlin panel causality test is used to identify the causal connection between predicted and explanatory variables. Moreover, the political risk index and renewable energy consumption can play a substantial role in the provision of environmental services, while *GDP* can degrade the environment further in the region.

The following section outlines the theoretical underpinnings of the study and incorporates an examination of pertinent literature. Subsequently, the third section delineates the empirical model and elucidates the econometric techniques applied. Moving forward, the fourth section engages in a discourse on the findings. The final section encompasses conclusive reflections and offers policy suggestions.

2. Literature Review

2.1 Nexus of political risk index and environmental poverty

The previous research work has focused mostly on energy poverty and environmental degradation, which directly or indirectly represent environmental poverty. An increase in energy poverty represents environmental poverty in countries. Furthermore, a pressing global concern today is environmental poverty, with a staggering 2.4 billion people lacking access to clean water and 2.3 billion lacking adequate sanitation services. Furthermore, as reported by the World Health Organization (WHO) and the International Energy Agency (IEA), over 1 billion individuals do not have access to clean fuels and advanced technologies. Moreover, a staggering 1.6 billion people are significantly affected by the risks posed by climate change (IPCC, 2022; IEA, 2023; WHO, 2022).

Environmental poverty refers to the deficiency of water and sanitation services and less or no access to clean fuel or technologies for cooking and heating. The direct linkage between the political risk index (*PRI*) and environmental poverty is scant in the literature; however, the indirect effects are mostly documented in previous research. For example, Khan, Haouas *et al*. (2023) examined the impact of financial inclusion on energy poverty while studying the role of a composite risk index and energy investment. The results indicate that financial inclusion leads to a reduction in energy poverty while the composite risk index increases energy poverty in emerging economies. Moreover, Xia *et al*. (2022) studied the link between fiscal decentralization and country risk and energy poverty by taking quarterly data from 2005Q1 to 2019Q4. The authors agreed that fiscal decentralization and country risk reduce energy poverty in the long run while also suggesting that the green focus of fiscal decentralization should be improved and lowering the country risk could further reduce energy poverty.

Lee *et al*. (2022) scrutinized the role of renewable energy innovation (REI) and the threshold and moderating role of climate risk on energy poverty in provincial data for China. The outcomes showed that lowering the climate risk would be conducive to energy poverty and decrease it in the long run. Kirikkaleli *et al*. (2022) found that income level (*GDP*) is one of the key determinants of environmental degradation in developing economies, particularly China, and also causes environmental poverty in the economy. The research also found that political stability should be enhanced to reduce environmental degradation and poverty in the economy. The outcomes further recommended that political stability should be promoted while tensions should be reduced to achieve long-term environmental sustainability. In the case of Brazil (Kirikkaleli and Adebayo, 2022), the political risk role was identified concerning environmental quality. The outcomes showed that political risk has a positive relation with environmental quality while the bidirectional connection is confirmed with time-varying causality between political risk and environmental quality.

2.2 Role of GDP and renewable energy

Furthermore, the level of income has positive effects on environmental protection and stimulates environmental services, which may reduce environmental poverty in general. For instance, Nawaz and Iqbal (2021) studied the role of cash transfers through different organizations to the poor population of Pakistan to observe its influence on environmental services. The authors found that cash transfers to 57% of the households which increase their income have a positive influence on environmental services and significantly reduce environmental poverty among households. The outcomes recommend that policymakers should expand these social protection programmes to provide better services in developing economies. Moreover, Ehigiamusoe *et al*. (2022) examined the connection between poverty, inequality, income and environmental pollution in different income group countries. The results indicate that income inequality leads to increased ecological emissions and pollution. To reduce emissions and pollution, authorities should focus on income inequality and poverty to protect environmental services. Similarly, Awad and Warsame (2022) scrutinized a heterogeneous panel of countries for the nexus of poverty and environmental degradation. The research included ecological footprint instead of CO_2 emissions and found that poverty and environmental degradation have bidirectional causality in Africa while no causal linkage exists in Latin America and Asia, which suggests that environmental quality is lower in Africa. The link between income and environmental degradation which causes environmental poverty was also observed by Amin *et al*. (2023), whose research included the nexus of renewable energy poverty, income and environmental pollution in the E9 countries. The results show that income inequality leads to environmental pollution while poverty alleviation leads to its reduction. The findings also indicated a bidirectional connection between income and environmental pollution.

Similarly, renewable energy substantially influences environmental poverty in different regions and countries. The literature on renewable energy consumption (*REC*) and environmental poverty is scant and the research focused on the influence of renewable energy on related factors of environmental poverty. For example, W. Wang *et al*. (2022) explored the link between *REC* and energy poverty by encompassing provincial-level data for China. Their results indicate that *REC* reduces energy poverty significantly in the eastern provinces while having a negative influence in the western provinces. Moreover, Zhao *et al*. (2022) examined the link between *REC* and energy poverty globally and concluded that heterogeneity exists in the results where energy poverty is significantly reduced through the use of *REC* in European economies while in the Asian economies, there is a weak connection with each other. Furthermore, Ceglia *et al*. (2022) observed that *REC* significantly reduces energy poverty and CO_2 emissions of Italian residents. Mukhtarov and Mikayilov (2023) explored the role of financial development and *GDP* through *REC* on environmental quality. The authors found that financial development and *GDP* have favourable effects on *REC*, which spurs environmental quality and also promotes energy efficiency. The research recommended that a sound financial system should be developed to promote an increase in *REC* and environmental quality services in countries across the world.

2.3 Summary and literature gap

The previous research is summarized with the conclusion that political risk is one of the related and substantial factors in environmental poverty while it is also observed that income level and renewable energy are leading factors and have a positive influence on environmental services and can help reduce environmental poverty across the world. However, countries with more income inequality, corruption and poor institutional quality will face challenges in reducing environmental poverty. Moreover, the literature is more concerned with single factors such as energy poverty and environmental degradation, however; very limited research into environmental poverty is observed in the previous literature which encompassed more SDGs and objectives of sustainable development. Besides, evidence on the role of income and renewable energy consumption and its influence on environmental poverty is scant and limited, which motivates us to examine the influence of the political risk index, *GDP* and *REC* on environmental poverty to fill the existing literature gap. The research will include a novel MMQR procedure on the empirical results in the panel data setting and could open doors for policymakers to apply the empirical results in relevant policies to achieve a sustainable development focus on the environment.

3. Theoretical Framework, Model Specification and Estimation Strategies

3.1 Theoretical framework

The present study explores the linkage between the political risk index (*PRI*) and environmental poverty (*ENVP*) along with the role of *GDP* and renewable energy consumption (*REC*). The link between *PRI* and *ENVP* is examined through different channels. A stable political economy reduces environmental poverty by increasing the efficiency of institutions and bureaucracy, which enhances focus on projects and goals helpful for environmental quality. Moreover, strong political institutions promote green investment, reduce transaction costs and make effective legislation and environmental regulations that enhance environmental quality in the countries. Besides, political institutions' effective performance and stringent regulations related to the environment promote a green economy and efficient technologies, which increase environmental stability and reduce environmental poverty. Conversely, political risk, which contains factors such as corruption, weak governance and uncertainty, increases environmental degradation and poverty. Governments increase political risk by relaxing environmental policies, allowing pollution and wastage, depletion of resources, income inequality and poor institutional performance. Moreover, resource curse theory and ecological modernization theory are considered in the connection between *PRI* and *ENVP*. When a country focuses on the resource rent and neglects the growth of other real economic sectors, it indicates poor institutional quality, weak governance, corruption and political instability, which can lead to resource depletion and environmental degradation. The latter theory suggests that using the profusion of resources efficiently and investing its revenues in the technological and innovation sectors can increase environmental quality because of its novelty and replacement of old technologies. Since the economies we examine are efficient and sustainable, we presume a negative influence of *PRI* on *ENVP*, *i.e.*, $\delta_1 = \delta ENVP/\delta REC < 0$.

There are different channels through which the income level (*GDP*) of households and countries affects environmental poverty differently. According to the environmental Kuznets curve (EKC) hypothesis by Grossman and Krueger (1991), an increase in *GDP* negatively influences the environment at the early stages of development because of the rapid utilization of resources and production of goods and services, while the impact of *GDP* on the environment becomes positive at the later stages when the economic expansion reaches its ultimate level. However, there are other channels that either promote or decrease environmental quality in the economy, *i.e.*, income, investments and consumption. The increasing role of income is mostly concerned with the country's environmental regulations and institutional framework to either allow increasing spending on energy-intensive goods or environmentally sustainable goods. It is believed that countries and their households will strive for the trade-off between economic expansion and environmental quality and therefore, most of the products having larger emissions should be foregone to promote environmental services and quality. Moreover, increasing investments in the traditional or energy-intensive sectors also increase emissions and degrade environmental quality. However, such investments can also be allowed in the green economic structure and energy-efficient technologies. Similarly, the unsustainable consumption of products and other goods increases emissions while also causing depletion of natural resources via its insensitivity, which may also harm environmental sustainability. Following the increasing steps of economies toward sustainable economic expansion, we expect that *GDP* will have a negative influence on environmental poverty, *i.e.*, $\delta_2 = \delta ENVP/\delta REC < 0$.

Renewable energy provides different transmission channels through which it affects environmental poverty. Sustainability theory is one of the theories where it is observed that *REC* replaces outdated technologies, reduces production inefficiencies and promotes sustainable economic expansion because these technologies are energy-efficient and sustainable due to their self-replenished nature and emit zero or fewer emissions. *REC* helps countries provide a source of sustainable energy that can reduce the depletion of resources and usage of fossil fuels. Similarly, these technologies also promote the efficient use of resources and such optimization leads to environmental sustainability because of the lower pollution and wastage. Developed countries and their companies are under more environmental pressures because of their stringent regulations to adopt renewable and cleaner energy products to enhance energy efficiency and promote environmental quality. However, in emerging and developing countries, having a lower level of renewable energy stimulates inefficiencies in their production and manufacturing setups, increasing costs of outputs, unemployment and income inequality, which causes lesser demand for products and reduces sustainable resources for environmental quality. Since economies in this research have mixed outputs of cleaner energies, we expect a positive influence of *REC* on *ENVP*, *i.e.*, $\delta_3 = \delta ENVP/\delta REC < 0$.

3.2 Model specification

Given the theoretical backdrop of the research, we propose the environmental poverty index to be constructed from the following indicators, which thoroughly cover the said index in the study. By using the principal component analysis, we compute the environmental poverty index from variables such as access to clean fuel technologies (taken as percentage of population), annual domestic freshwater withdrawals (taken as percentage of total freshwater withdrawals), mean annual exposure to PM2.5 air pollution (measured as micrograms per cubic meter), biodiversity (taken as dataset of Red List Index), municipal waste generation and treatment (thousands of tonnes) and total greenhouse gas emissions (kt of CO_2 equivalent). The explanatory variables are the political risk index, income (*GDP*) taken as US dollars constant in 2015 and *REC* (renewable energy consumption) is taken as renewable energy out of total energy. The data for *PRI* are collected from ICRG (2023) and for *GDP* and *REC* from World Bank Group (2023).

The weighted average of the environmental poverty index is given below:

$$\begin{aligned} &ENVP_{Year} = (W_1 * Access\,to\,clean\,fuels\,and\,technologies\,for\,cooking_n + \\ &W_2 Annual\,freshwater\,withdrawals,\,domestic_n + W_3 Tree\,cover\,loss_n + \\ &W_4 PM\,2.5\,air\,pollution,\,mean\,annual\,exposure_n + \\ &W_5\,Municipal\,waste\,generation\,and\,treatment_n + \\ &W_6 Total\,greenhouse\,gas\,emissions_n + \varphi_t \end{aligned} \tag{1}$$

The main model of the study is as follows:

$$ENVP_{ti} = \alpha_1 + \beta_1 PRI_t + \beta_2 GDP_{ti} + \beta_3 REC_{ti} + \varphi_t \tag{2}$$

where *i* denotes a cross-section of countries while *t* represents time in years. Environmental poverty is the predicted variable while the covariates are the political risk index, income (*GDP*) and renewable energy consumption. The *i* for each country encompasses Austria, Belgium, Chile, Colombia, Costa Rica, Czechia, Estonia, Finland, Greece, Hungary, Ireland, Italy, Japan, Latvia, Mexico, the Netherlands, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland and Turkey (taken from a group of countries known as OECD).

3.3 Estimation procedures

To understand the panel data empirically, we employ different procedures which at first include cross-sectional dependence and slope heterogeneity. These two procedures are to be employed before the unit root estimation procedure to eliminate the possibilities of distortion in the unit root and static properties of the data. Moreover, economic shocks, globalization, urban changes, financial and economic crises and situations related to these countries are all based on cross-sectional dependence (CD). These issues might lead to spurious outcomes; thus, we employ the CD test (Pesaran, 2007) before the application of the unit root procedure to examine the CD issues among the panel data series. The equation for the CD test is as follows:

$$CD_{test} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\tau}_{ik}\right) \tag{3}$$

The H_0 of the study assumes no dependent observations while H_1 assumes dependence on outcomes.

Another diagnostic procedure is slope heterogeneity (SH) test (Hashem Pesaran and Yamagata, 2008), which determines whether all entities or countries differ from each other and there is no homogeneity in the observations or outcomes. The SH test can be further explained as a clear variation between predicted variables and their covariates across entities, which is advantageous because it facilitates understanding of the differences across entities. The equation for the SH test is given below:

$$\tilde{\Delta}_{HPY} = (N)^{\frac{1}{2}} (2k)^{-\frac{1}{2}} \left(\frac{1}{N} \tilde{S} - k \right) \tag{4}$$

$$\tilde{\Delta}_{ASH} = (N)^{\frac{1}{2}} \left(2k \left(\frac{T-k-1}{T+1} \right)^{-\frac{1}{2}} \left(\frac{1}{N} \tilde{S} - 2k \right) \right) \tag{5}$$

where $\tilde{\Delta}_{HPY}$ and $\tilde{\Delta}_{ASH}$ express the null and alternative hypotheses of slope coefficients.

After the application of SH and CD tests, we employ a panel unit root test or a static procedure for data. The data are examined empirically for the SH and CD procedures, we employ the second-generation unit root test, which is an efficient procedure except for structural breaks; therefore, we employ the CIPS panel unit root procedure of Pesaran (2007). The procedure is mainly based on the time series method ADF (Dickey and Fuller, 1981) which indicates that cross-lagged average values are to be taken along with their differences to determine whether the unit root is present outside the line. The CIPS test is more advantageous than its predecessors because it encompasses cross-sections and the procedure is more effective and powerful. The CIPS procedure is modelled as follows:

$$\Delta W_{i,t} = \delta_i + \delta_i Z_{i,t-1} + \delta_i \overline{W}_{t-1} + \sum_{l=0}^{p} \delta_{il} \Delta \overline{W}_{t-l} + \sum_{l=1}^{p} \delta_{il} \Delta W_{i,t-1} + \mu_{it} \tag{6}$$

The t-statistics for the CIPS are articulated as:

$$CI\hat{P}S = N^{-1} \sum_{i=1}^{n} CADF_i \tag{7}$$

where *CADF* signifies cross-sectionally augmented Dickey–Fuller.

After the application of the unit root test, we employ the Westerlund cointegration error correction method (Westerlund, 2007) to observe the long-run equilibrium and correlation between heterogeneous variables. Moreover, the method includes the components of cross-sectional dependence and slope heterogeneity and resolves the issues of CD. The alternative hypothesis says that the variables have long-run equilibrium, while the null hypothesis shows no relationship.

Since the data are panel, they may have issues of cross-sectional dependence and slope heterogeneity, which leads to spurious estimations and biased errors. These conflicting estimations and doubtful outcomes erupt due to the general shocks among economies, financial crises and breaks, which leads to CD and SH existence in the data. Therefore, we employ cross-sectionally augmented auto-regressive distributive lags (CS-ARDL), (Chudik and Pesaran, 2015), which express the application of dynamic correlated estimators for the mentioned problems. The method is more efficient and robust than pooled mean group, augmented mean group and common correlated effect mean group. The CS-ARDL is employed because it can fit in every dimension of the panel data sample and also incorporate a mixture of static or non-static order along with the provision of its equilibrium outputs. Generally, the CS-ARDL is presented as:

$$\Delta Y_{i,t} = \alpha_i + \sum_{l=1}^{P} \alpha_{i,t} \Delta Y_{i,t-1} + \gamma_i \overline{X}_{t-1} \sum_{l=0}^{P} \alpha_{i,t} EXV_{s,i,t-1} + \sum_{l=0}^{1} \alpha_{i,t} \overline{CSA}_{i,t-1} + \varepsilon_{it} \quad (8)$$

Since the panel data have cross-sectional and slope heterogeneity issues that the traditional procedures might not tackle robustly, we also employ an augmented mean group (AMG), which not only accounts for issues such as SH, CD and non-static common factors but also detects common unobserved correlated factors and also accounts for limited or unlimited factors and global shocks, financial disturbances; besides, it also proves to be an alternative to year dummies and dynamic common procedures. Thus, AMG is employed mostly in cases where there are issues such as non-stationary common factors and omitted common factors.

Finally, we employ the causality test to determine the causal connection between all the variables by encompassing the Granger causality panel test procedure, which is known as the Dumitrescu–Hurlin test. The test is useful when the cross sections and time series are not equal while CD and SH are present in the data.

4. Results and Discussion

Table 1: Descriptive statistics

Variables	***ENVP***	***GDP***	***PRI***	***REC***
Mean	−3.732347	6.7332	75.37300	21.32114
Median	−0.434478	3.747845	76.95833	16.95833
Maximum	4.232839	4.583578	93.66667	62.37000
Minimum	−0.709449	1.8134231	44.08333	0.770000
Std. dev.	1.000001	9.009782	10.90926	14.96211
Skewness	2.532601	2.927795	−0.945135	0.785984
Kurtosis	9.628365	12.07429	3.503389	2.823546

Source: Authors' own calculations

Our research begins with a general explanation of the variables in Table 1, which indicates that *ENVP* (environmental poverty index) has an average value of −3.73, while its maximum value is 4.5 and its minimum value is −0.70. Moreover, the average value of the co-variates is positive and growing in a similar direction. The dispersion of these values of the variables from the average values is checked through standard deviation; we can see that SD values are in line and show less dispersion of the variables. Moreover, the distribution of the data normality is checked through skewness and kurtosis. The outcome indicates that the modelled variables are positively skewed except *PRI*, which is negatively skewed, while the kurtosis results show that *PRI* and *REC* have normal tails while *ENVP* and *GDP* have heavier tails.

Table 2: Slope heterogeneity test

Model	Δ (*p*-values)	$\Delta_{Adjusted}$ (*p*-values)
	14.186*** (0)	16.526*** (0)

Note: The significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: Authors' own calculation

Table 2 provides the results for slope heterogeneity, which reveal that the covariates are heterogenous and the slope coefficients of the variables are extremely significant at 1%. The modelled variables *ENVP*, *GDP*, *REC* and *PRI* have placement at slope heterogenous coefficients. Thus, the alternative hypothesis of the research (the slope is heterogeneous) should be accepted, while the null hypothesis of slope homogeneity is rejected.

Table 3: Cross-sectional dependence

Variable	CD test	Correlation
ENVP	16.956**	0.68
GDP	48.083***	0.80
REC	30.489***	0.75
PRI	20.203***	0.45

Note: The significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: Authors' own calculations

The estimated results for cross-sectional dependence (CD) provided in Table 3 confirm that all the concerned variables are found significant at 1% and 5%, demonstrating the dependency of OECD economies on each other. Moreover, it is observed that certain changes in environmental poverty and its reduction would occur mainly in cooperation of these economies. Therefore, we accept the alternative hypothesis of CD and reject the null hypothesis of no CD in the OECD economies.

Table 4: CIPS unit root test (trend and intercept)

Variables	Level (0)	Difference (1)
ENVP	–2.105	–4.564***
GDP	–1.347	–3.127***
REC	–2.948**	–
PRI	–1.675	–3.086***

Note: *** is for 1%, ** for 5% and * is for 10% significance level.
Source: Authors' own calculations

Table 3 shows the unit root estimations obtained using the CIPS unit root test, which confirm that no unit root issue is present among the concerned variables of the study. Moreover, the results further confirm that all the variables are found static at first difference except *REC*, which is static at level. This leads to the acceptance of the alternative hypothesis while rejecting the null hypothesis of variables being static at level.

Table 5: Westerlund cointegration test

Model	G_t (*p*-values)	G_a (*p*-values)	P_t (*p*-values)	P_a (*p*-values)
	–2.692*** (0)	–7.756 (0.517)	–8.311* (0.078)	–6.614** (0.035)

Note: The significance level is denoted by *** for 1%, ** for 5% and * for 10%.
Source: Authors' own calculations

Table 5 illustrates the Westerlund cointegration test, which offers four error correction methods; the procedure helps explain the short-term dynamics and long-run equilibrium along with encompassing the time series and cross-sectional dependence structure of the panel data series. Thus, with the exception of G_a, the remaining three tests confirm that long-run equilibrium exists in the panel and also the G_t test is more efficient and significant, showing the long-run connection between the predicted variable of environmental poverty and the explanatory variables.

Table 6: Short-run results (CS-ARDL)

Variable	Coefficient	Std. error	*t*-statistic	Prob.
REC	−0.482674**	0.2138412	−2.2634	0.0243
PRI	−0.0229446	0.2128065	−0.11243	0.9142
GDP	1.2136913**	0.5122515	2.3754	0.0180

Note: ***, ** and * show significance at 1, 5 and 10% levels respectively.
Source: Authors' own calculations

The empirical outcomes of the research are reported in Tables 6 and 7. Table 6 designates short-run CSARDL results, which imply that renewable energy consumption (*REC*) and political risk index (*PRI*) harm environmental poverty with a coefficient of −0.48% and −0.022% respectively in the short run, while *GDP* has a positive influence on environmental poverty (*ENVP*) in the short run with a coefficient of 1.21%. It is further illustrated that *PRI* has a negative influence but is insignificant in the short run, while the impact of *REC* and *GDP* is shown to be significant at 5% and 10% respectively.

Table 7: Long-run results (CS-ARDL)

Variable	Coefficient	Std. error	*t*-statistic	Prob.
***ECM*(−1)**	−0.86311***	0.0592685	−14.581	0.0000
GDP	1.457941***	0.5202245	2.8031	0.0051
PRI	−0.0345582***	0.0091583	−3.778	0.0000
REC	−0.5834983***	0.2182956	−2.6723	0.0081

Note: ***, ** and * show significance at 1, 5 and 10% levels respectively.
Source: Authors' own calculations

Besides, the long-run results are shown in Table 7, which exhibits that a one-percent change in *GDP* increases environmental poverty (*ENVP*) with a large coefficient of 1.45% with the extreme significance of 1%. Moreover, the coefficients of *PRI* and *REC* are shown to have a negative influence on *ENVP* with coefficients of −0.034% and −0.58% in the long run. This indicates that *PRI* and *REC* in the OECD economies induce environmental services and reduce environmental poverty in the long run.

4.1 Discussion

The research elucidates findings on the variables of environmental poverty through the application of the cross-sectional autoregressive distributive lags (CS-ARDL) model, which accounts for cross-sectional issues as well as heterogeneity and non-stationarity issues of the variables. The results are provided through the CS-ARDL procedure for both the short and long run. The results suggest that the political risk index has a negative influence on *ENVP* in both the short and long run. However, the short-run results are insignificant and inconclusive. The long-run negative influence posits proper changes in the environmental poverty of OECD economies. It is observed that OECD economies are mostly developed and politically stable economies, which have a lower risk of political instability. Moreover, the economies have high standards of environmental regulations, efficient bureaucracy and enhanced institutional qualities that allow more investments and increase the citizens' income levels. The per capita income of OECD economies is much higher compared to BRICS and other developing and emerging economies. The citizens' increasing income increases their expenditure and investments in environmental services, allowing the countries to have lower environmental degradation and higher environmental qualities. Moreover, the strong economic institutions of the OECD countries allow investors to invest in long-term renewable projects, which pays off in the longer run, compared to the higher political risk in other economies hindering investments in environment-friendly projects because of the risk of political instability, corruption and weak governance. Furthermore, with an unstable government, countries would be unlikely to impose environmental regulations and may be more likely to allow deforestation and higher-emission projects, which can further deepen the environmental poverty crisis. Authorities should further enforce environmental regulations and raise awareness regarding environment-friendly projects, which can lower environmental poverty and achieve sustainable development. The results are found to be similar to the observations of Qin *et al*. (2021) and dissimilar to those of Adebayo *et al*. (2022).

Against this backdrop, *GDP* induces *ENVP* in OECD countries. The results for *GDP* are significant in both the short and long run. This provides an economic understanding that the OECD countries have lower political risk and an improved political risk index because of their strong democratic institutions and efficient financial systems. As a result of this, investments, trade and consumption increase pollution and environmental degradation because of the rapid economic expansion. With lower political risk, the income levels increase, which leads to high consumption of energy-intensive goods and causes depletion of resources, which creates waste and pollution. Another channel is investments: in politically stable economies, investments from local and foreign investors increase, leading to funding in both renewable and non-renewable energy projects. These increased investments in non-renewable energy projects cause pollution havens, which leads to increasing emissions and lessening environmental services. Policymakers should promote sustainable economic development and strive for the tradeoff between environmental and economic outcomes to obtain sustainable development goals. Our findings are similar to the conclusions of Acheampong and Opoku (2023).

Conversely, the role of renewable energy consumption (*REC*) is positive for environmental quality and enhanced environmental sustainability. The reasons for *REC* are significant and relevant in both the short and long run. Since renewable energy projects promote efficient and effective products, this could prove to be a game changer in the reduction of environmental poverty across the world, particularly in OECD economies. Despite the economic system of these economies, environmental poverty exists in one way or the other. It can exist in the access to energy, due to high transport or heating fuel costs, business power, clean water, etc. Renewable energy projects are predicted to have a negative impact, which indicates that clean energy promotes environmental quality because of its self-replenishing nature, lower or zero emissions and implementing it into the industry after the announcement of SDGs. Moreover, air pollution, which is one of the bigger problems of climate change even in the OECD economies generated from the burning of fossil fuels, could be removed through the use of renewable energy. In both the rural and urban areas, renewable energy can prove to be a sustainable source of energy, useful in reducing environmental poverty and providing an efficient alternative to fossil fuels. However, renewable energy projects are intermittent and costly, which could make them difficult to integrate into the electricity grid. To realize these opportunities and solve the problems, the policymakers should enhance the structure and mechanisms of renewable energy to store it and supply it into the grid and enhance the environmental quality. Our results are analogous to the observations of Khan, Badeeb *et al*. (2023).

Table 8: Augmented mean group (AMG)

Variable	Coefficient	Std. error	*t*-statistic	Prob.
GDP	0.6150481***	0.1808098	3.40322	0.001
REC	−0.3765138***	0.0971159	−3.88234	0.000
PRI	−0.3750753***	0.1885399	−1.99342	0.047
Constant	−7.681292***	2.128224	−3.613234	0.000

Note: ***, ** and * show significance at 1, 5 and 10% levels respectively.
Source: Authors’ own calculations

Table 8 shows robustness results of the AMG estimator, which is useful in accounting for cross-sections, non-stationary issues and heterogeneity issues. The results indicate that *GDP* has a positive impact on *ENVP* while *REC* and *PRI* induce environmental quality in OECD economies.

The estimates of *GDP* with a coefficient of 0.16% and *REC* and *PRI* with coefficients of −0.37% and −0.37% respectively are provided. The results reported by the AMG estimator further strengthen our results from the CS-ARDL and confirm that our results are robust, efficient and valid. The robust results also prove that an improved *PRI* and stimulating role of *REC* could lessen environmental poverty. However, a sustainable *GDP* is necessary to alleviate environmental poverty in the OECD economies.

Table 9: Pairwise Dumitrescu–Hurlin panel causality test

Null hypothesis	W-stat.	Zbar-stat.	Prob.
GDP* → *ENVP	7.08382***	15.78080	0.0000
ENVP* → *GDP	1.37946	0.60039	0.5482
REC* → *ENVP	5.73595***	12.19380	0.0000
ENVP* → *REC	1.94841**	2.11448	0.0345
PRI* → *ENVP	2.26482***	2.95650	0.0031
ENVP* → *PRI	1.26183	0.28736	0.7738

Note: ***, ** and * show significance at 1, 5 and 10% levels respectively.
Source: Authors' own calculations

The causal connection results are reported in Table 9, which are obtained using the Dumitrescu–Hurlin panel causality test. The causality results in Table 9 show both bidirectional and unidirectional causality relationships between variables. The estimator assures a bidirectional linkage between *REC* and *ENVP*, while a unidirectional connection is found between *GDP* and *ENVP* and *PRI* and *ENVP*. It is observed that changes in *REC* will have a feedback effect on environmental poverty, and the same applies to changes in environmental poverty towards *REC*. However, no feedback effect is found from *GDP* and *PRI*.

5. Conclusion and Policy Implications

5.1 Conclusion

Environmental poverty has been a searing global issue with its dramatic effects on populations across the world, including both developed and developing economies. The high energy costs, volatility of resources and their prices, pollution and wastage, weak governance, poor institutional quality and political instability are the outcomes of environmental poverty in the current world order. To examine the factors that lessen or induce environmental poverty, we examined the role of political risk index, income and renewable energy consumption in environmental poverty in OECD economies for the period 2004–2022. We employed several panel econometric procedures, which included cross-sectional dependence and slope heterogeneity, CIPS unit root circle for the identification of unit roots and Westerlund cointegration for long-run connection among variables. Besides, the study employed cross-sectional autoregressive distributive lags (CS-ARDL) to identify both the short-term and long-term impacts of explanatory variables on environmental poverty. The results indicate that the variables are heterogenous and cross-sectionally dependent. Moreover, unit roots are found within the unit root circle, which implies that variables are static at first difference and long-run equilibrium exists among variables. The empirical results illustrate that the political risk index reduces environmental poverty. A one-percent improvement of the political risk index lowers environmental poverty by −0.022% and −0.034% respectively. However, the results for *PRI* are inconclusive in the short run but effective in the long run. Since the OECD countries have lower political risk and effective *PRI*, economic and financial activities are spurred, leading to a positive influence of income on environmental poverty. A one-percent increase in income level (*GDP*) increases environmental poverty in OECD countries by 1.21% and 1.34% in the short and long run. Conversely, the results for *REC* are negative in both the short and long run and conclude that *REC* significantly reduces environmental poverty in the region. Besides, the robustness analysis employed using an augmented mean group (AMG) had similar and robust results. The Dumitrescu–Hurlin panel causality test reported that *REC* and *ENVP* have a bidirectional causal linkage and provide feedback to each other while *GDP* and *PRI* have a unidirectional connection and no feedback effect was found. These results reveal that renewable energy investments must further be attracted with a stable political risk index to achieve sustainable economic expansion and improve environmental services.

5.2 Policy implications

The following policy recommendations are drawn from the above conclusions. Firstly, it is observed that political risk reduces environmental poverty more effectively in the long run, which suggests that policymakers should promote investments in the renewable energy sector, its research and development and allow tax breaks and subsidies to people for environmental services to promote inclusive sustainability and reduce GHG emissions in the short run. Moreover, policymakers should support the transition of renewable energy products by managing political stability and enhancing the quality of institutions and bureaucratic practices to enhance environmental initiatives in the region. Secondly, *GDP* worsens environmental poverty; thus, policymakers should expand the economic sectors while targeting the use of clean and efficient energy products to reduce the depletion of resources, pollution and wastage of clean water. Moreover, sustainable practices should be adopted based on cleaner energies, energy-efficient technologies and development skills that promote sustainable environmental practices. Thirdly, *REC* should be promoted by policymakers, the R&D and awareness programmes should be further integrated with the economic structure in the short run while carbon pricing and energy efficiency standards should be set for the industries along with international collaboration on cleaner energy projects to promote environmental quality.

5.3 Research limitations

The research is limited to a specifically developed region. Thus, future researchers can explore other regions along with new or similar factors of environmental poverty. Moreover, the study sample should be brought up to date to further cover the issue of environmental poverty in the current climatic context. Moreover, future studies can also observe the break years to further elaborate on the influence of the relevant factors on the environmental poverty situation.

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