Investigating the Factors Affecting Natural Disinvestment Component: A Panel of Different Income Group

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Abstract

This study examined the correlation between economic growth and the impact on the environment, specifically focusing on the concept of environmental sustainability. The World Bank's Adjusted Net Savings (ANS) data is utilized in this study to gauge the strain on the environment, specifically through the measurement of natural disinvestment. This measurement encompasses the cumulative effects of carbon dioxide (CO2) damage, as well as depletions in minerals, energy, and forest resources. This study uses panel data with respect to the endogeneity of explanatory variables to estimate the real effect of per capita income and the other variables on environmental pressure. In this regard, employing the panel Fixed-Effects Instrumental Variable (IV) methodology, the data from 213 countries have been used in the period from 1990 to 2018. A special feature of this study is the consideration of the domestic consequences of environmental pressures and the comprehensive estimation of the costs of natural resource degradation for countries with different income levels in the form of an ANS index. Through regression analysis, it has been discovered that there is a direct correlation between income and the impact on the environment in developing nations. However, this relationship is notably more pronounced in low-income countries compared to high-income countries. Additionally, the study reveals that trade expansion contributes to an increase in environmental pressure across all groups of countries. An increase in the school enrolment rate can affect the environment in developed and high-income developing countries. Moreover, the variable effect of capital openness on environmental pressure was estimated to be positive for developed and high-income countries. However, this effect was found to be negative for low-income countries. Finally, the result showed that developing countries should improve their legal structure and also reduce the bureaucracy and complexity of the laws.

Keywords: Economic growth; Environmental sustainability; Developing country; Panel data; Instrumental variables

1. Introduction

Human activities are currently causing unprecedented climate change on a global scale. The link between human activities and the rapid extinction of species, deforestation, and the depletion of natural resources is highly probable (Spangenberg, 2007; Xi-Liu & Qing-Xian, 2018; Karelin et al., 2020). In the past, questions about how economic activities impact the environment were rare, as historical records suggest that human-related environmental disasters were infrequent. Localized environmental issues were manageable, and people could live without major concerns or questions (Hahnel, 2015). However, since the industrial revolution, the world population has grown quickly, leading to resource shortages and environmental problems. This has prompted a shift towards viewing the Earth as a finite spaceship (UNEP, 2015).

The traditional perspective prioritizing economic growth for human welfare has been challenged, particularly after the global economic crisis in 2008 (Aşıcı, 2012). According to neoclassical economic theory, economic growth is tied to the accumulation of physical capital. However, this narrow focus on capital accumulation overlooks other aspects of well-being, such as natural resources, human capital, quality of the environment, and leisure time. Merely increasing GDP per capita does not guarantee improved welfare (Siche et al., 2008; Singh et al., 2012; Slesnick, 2020). Some proponents of "degrowth" argue that human progress is possible without relying on continuous economic growth (Schneider et al., 2010), but this perspective has faced criticism from other scientists (Jackson, 2009). On the other hand, advocates of the green economy believe that investments in sustainable sectors like energy and construction can create green jobs and transition away from carbon-based economies (Barbier, 2010).

In low-income and middle-income countries, natural resources often constitute a significant portion of their exports (Costantini & Mooni, 2007). Human demand has led to environmental degradation, especially since the mid-1970s, and the gap is widening (Ewing et al., 2010). Statistics indicate that human activities account for over 95% of greenhouse gas emissions, intensifying climate change and drawing global attention to environmental degradation (Herwartz & Walle, 2014; EIA, 2018). The dissatisfaction with conventional development approaches during the global economic crisis has sparked interest in rational planning to achieve environmentally sustainable economic growth in low and middle-income countries (Schneider et al., 2010; Jackson, 2009). The ultimate goal is to achieve the highest standard of living in high-income countries while minimizing environmental pressure.

Numerous studies have explored the relationship between the environment and economic development, often using the Environmental Kuznets Curve (EKC) framework (Ehrhardt-Martinez et al., 2002; Esty & Porter, 2005; Mazzanti & Zoboli, 2009; Boulatoff & Jenkins, 2010; Al-Mulali et al., 2015; Ozokcu & Ozdemir, 2017; Yang et al., 2017; Venevsky et al., 2020). The EKC suggests an inverted U-shaped curve, indicating that economic growth and environmental quality initially have a negative relationship until a certain level of development is reached. Beyond that point, society strives for economic growth while improving environmental quality (Pao and Tsai, 2011; Ganda, 2019b). While some studies support the EKC hypothesis, there are critics who question the positive impact of economic growth on environmental quality (Arrow et al., 1996).

Speaking of a unique curve for all types of environmental degradation is not possible. Therefore, doubts have been raised as to the EKC hypothesis (Venevsky et al., 2020). Hence, It is necessary to develop indicators for policy in line with the principles of sustainable development. Several steps have been considered for measuring the environmental impacts of economic activities through the development of environmental indicators and criteria in the context of conventional accounting. Indicators relating to income and the environment can be enumerated as

Environmental Sustainability Index (ESI) (World Economic Forum; WEF, 2001) Environmental Performance Index (EPI) (Bohringer & Jochem, 2007; Balezentis et al, 2016), Environmental Vulnerability Index (EVI) (Singh et al., 2012; Sanchez et al., 2018), Index of Sustainable Economic Welfare (ISEW) (Centre for Environmental Strategy (CES), 2000), green net national product (United Nations Environment Programme (UNEP), 2000), Ecological Footprint (EF) (Wackernagel et al., 1999; Weinzettel et al., 2014; Aşıcı & Acar, 2015; Ahmad et al., 2020; Destek & Sinha, 2020; Nathaniel & Khan, 2020; Ahmed et al., 2021), and Adjusted Net Savings (ANS) (Pardi et al., 2015; Poltarykhin et al., 2018; Larissa et al., 2020; Roeland & de Soysa, 2021).

The relationship between income and environmental sustainability, EF and ANS (also called Genuine Savings) indices other than the listed indicators to measure quality of life is more appropriate to assess the potential damage caused by environmental problems (Singh et al., 2012). The use of resources consumed, regardless of country of origin where the extraction (production) is criticism of the EF. Due to the fact that "some consumers can displace the environmental consequences associated with their use of the trade", the EF index is inappropriate for the purpose of this study. In contrast, using the ANS, the effect of income growth on the sustainability of the domestic environment can be seen (Aşıcı, 2012) Because this component represents a lack of the natural disinvestment component of ANS is characterized by combining three forms of capital physical, human, and natural.

The idea of ANS was formally introduced by the World Bank in 1992. ANS is defined as national net savings plus training costs, minus energy reduction, mineral reduction, net forest reduction, and damage from carbon dioxide pollution and particulate emissions (World Bank, 2020). The advantages of ANS compared to the conventional savings rate in terms of showing the real well-being of society have been proven in several studies (Gnegne, 2009). The ANS is a reliable accounting method that can measure the depletion of natural resources and the impact of environmental damage on the economy with negligible error (Merko et al. 2019; Larissa et al., 2020; Fakher et al., 2023). When ANS is negative, it may indicate that wealth is declining. Also, when the ANS is positive, it may indicate that wealth is growing (World Bank, 2020). ANS is a comprehensive indicator for measuring sustainable development from the perspective of savings as investment and accumulation of wealth. This economic dimension of sustainability shows that for a sustainable development path, an economy must maintain a positive ANS rate (Pardi et al., 2015).

Literature review

In recent decades, as environmental instability has increased, the assessment of the drivers of environmental indicators has expanded. In this context, there has been a large body of studies on the impact of economic growth on environmental quality within the framework of the EKC concept. However, the findings of these studies due to the diversity in the range of data used, the extent of use of explanatory variables and their proxies, the variety of analysis methods adopted, and the characteristics of variables in countries and regions, always have many discrepancies (Nathaniel & Khan, 2020). In this context, merchandise trade leads to a significant increase in the possibilities of economic growth, but it is usually associated with high pollution and increasing pressure on the environment (Khan et al., 2021). The impact of trade on environmental degradation is influenced by the scale effect, composition effect and technique effect (Grossman & Krueger, 1991). The scale effect shows that the economic growth caused by trade leads to an increase in the production rate, energy consumption and greenhouse gas emissions. The compounding effect argues that when economic development reaches a certain level, the intensity of greenhouse gases produced by trade will peak and gradually decrease. The technical effect also shows the impact of knowledge transfer and advanced technologies in production and emissions reduction (Tachie et al., 2020). In studies of the impact of trade on environmental pressures, researchers have used different proxies for trade in their models. Most researchers have used the degree of trade openness (the ratio of imports plus exports to GDP). Some authors use only exports as a proxy for trade. Some studies have also used the merchandise trade (GDP%) index (Khan et al., 2021). For instance, Al-Mulali and Ozturk (2015) within the framework of the EKC concept analyzed the effects of economic growth, energy consumption, political stability, the share of trade in GDP, and the rate of rural-urban migration on the ecological footprint as an indicator of environmental quality. In this study, the countries of the Middle East and North Africa were considered and the data of the studied variables during the period 1996 to 2012 were investigated. The results of this study showed that trade openness and political stability affect the ecological footprint.

In the existing literature, the rule of law index is also one of the variables that is always considered to be related to the quality of the environment. It is expected that by improving the ability of countries to enforce the rule of law, the pressure on nature will decrease. However, it is important to note that the existence of laws and regulations does not necessarily guarantee their implementation (Muhammad & Long, 2021).The level of education in society is also one of the factors influencing the environment. According to the theory, as the average years of education increase and the number of students increases, the quality of the environment is likely to improve (Alam, 2010; Zafar et al., 2020). There is a strong literature confirming the impact of democracy and good governance on environmental quality (Ali et al., 2020). Indeed, with the improvement of democracy, we can hope for effective and appropriate implementation of government laws and regulations to achieve better environmental performance (Jahanger et al., 2022). However, the effect of democracy on increasing CO_2 emissions is positively estimated in the studies of Chou et al. (2020) and Adams and Nsiah (2019). Congleton et al. (1992) also showed that democracy has side effects, while autocracy has a positive effect on the environment in the long run.

The use of the ANS index as a criterion for measuring environmental pressure and assessing the factors influencing it has been explored in a number of studies. For example, Aşıcı (2012) examines the relationship between economic growth and environmental quality within the EKC concept by examining the effects of economic growth variables, population density, literacy level, trade liberalization, and political indicators on ANS as an indicator of pressure on nature in 213 The country paid during the period 1970 to 2008. In this study, the instrumental variables method of panel data was used to estimate the effects. The findings of the study showed that economic growth, trade liberalization, and political indicators of countries are factors affecting environmental pressures. Ganda (2019a) evaluated the impact of the variables GDP per capita, domestic credit to the private sector, and foreign direct investment on the ANS index for OECD countries. The results, using the method of GMM analysis, show that the Kuznets curve can be demonstrated for the years 2001 to 2012. In the study Roeland & Soysa (2021), the effect of per capita income (representing economic growth), democracy index, urban population, and population density on the ASN index for 170 countries during the years 1970-1970 was evaluated. The results showed that democracy and higher incomes reduce the chances of eco-friendly production and increase pollution and degradation of nature. Din et al. (2021) analyzed the relationship between sustainable development, ANS, financial development, economic growth, and resource rents using the panel least squares method for the emerging economies of South Asia during the years 1990-2020. The results showed that the index of sustainable development, financial development, and economic growth have a positive and significant effect on ANS. Fakher et al. (2023) also used the ANS as a proxy for environmental deterioration in order to assess the impact of renewable and non-renewable energy on this index.

The objective of this study is to conduct a thorough literature review to identify the key variables that contribute to the strain on the environment and assess their impact on the Adjusted Net Savings (ANS) index. An important aspect of this research is the careful selection of an appropriate estimation method that adequately addresses the issue of endogeneity associated with certain explanatory variables, such as real per capita income, which has often been overlooked in previous studies. Moreover, this study investigates the influence of various factors on the environment, examining each separately for different countries based on their level of development and income, building upon the findings of Aşıcı (2012) and Destek & Sinha (2020). The primary aim is to explore the causal relationships between income and environmental pressure, with a specific focus on domestic environmental sustainability. While economic growth impacts the environment both domestically and globally, this study specifically concentrates on its repercussions within a country. The study utilizes the ANS index as an indicator, encompassing data from 1990 to 2018 and covering 213 countries classified into developed countries, high-income developing countries, higher middle-income developing countries, lower middle-income developing countries, and low-income developing countries. To examine these relationships, a panel dataset is employed, and fixed-effects instrumental variable regression is utilized. By adopting an environmental sustainability perspective, this study aims to investigate the correlation between economic growth and the strain on the environment. The pressure on nature is evaluated using the natural disinvestment component of the ANS data from the World Bank, which incorporates measures such as energy, mineral, net forest depletion, and carbon dioxide damage. It is worth noting that this study specifically focuses on the domestic consequences of environmental issues and highlights the significance of utilizing the natural disinvestment components of the ANS index. Consequently, the advantage of this study over previous research lies in its comprehensive utilization of the ANS index and its consideration of the endogenous aspects of the economic growth variable across different countries.

2. Methodology

The present study uses instrumental variable regression with panel data to check the relationship between log real income per capita and log real pressure on nature per capita. Pressure on nature in constant 2011 US$ is defined as a dependent variable which is the sum of CO_2 damage per capita (CDD), mineral depletion per capita (MD), energy depletion per capita (ED), and net forest depletion per capita (NFD) (Aşıcı, 2012).

$$PN = CDD + MD + ED + NFD \quad (1)$$

Pressure on nature is measured by the natural disinvestment component of the ANS data of the World Bank (World Bank, 2018). An analysis is performed on five groups of countries including developed countries, high-income developing countries, upper middle-income developing countries, lower middle-income developing countries, and lower-income developing countries which are based on World Bank classification. In our study, the extended model is used as follows (Aşıcı, 2012):

$$\begin{aligned} \log(PN_{it}) &= \alpha + \beta_1 \log(G_{i,t-1}) + \beta_2 Log(POPDEN_{it}) \\ &+ \beta_3 \log(EN_{it}) + \beta_4 \log(OPEN_{it}) + \beta_5 (RL_{it}) \\ &+ \beta_6 (CO_{it}) + \beta_7 (DEMO_{it}) + u_i + \varepsilon_{it} \end{aligned} \quad (2)$$

Log (PN_{it}) is log real per capita pressure on nature, Log ($G_{i,t-1}$) is the lagged value of log real income per capita (constant 2011 international dollar), Log ($POPDEN_{it}$) is log population density (total population divided by land area (km^2)), Log (EN_{it}) is log school enrolment rate (secondary school enrollment rate, total), Log ($OPEN_{it}$) is log merchandise trade (GDP%), RL_{it} is the rule of law index (rule of law captures perceptions of the quality of contract enforcement, property rights, police and courts, and the likelihood of crime and violence, as well as the extent to which agents trust and abide by the rules of society. The value of this index is between -2.5 and 2.5), CO_{it} it is capital account openness index (the degree of the capital account openness. Ranges from 2.5 (highly open) to - .83 (least open).), and $DEMO_{it}$ is democracy index (combined polity score, normalized 0 - 1). This equation is estimated separately for different groups of countries according to the classification. To this end, panel regression analysis with 213 different countries between 1990 and 2018 was used. Data on the variables derived by the World Development Indicators Database (WDI) of World Bank, Worldwide Governance Indicators (WGI), and Polity IV project database (PPD). The Stata software is used for the estimation of the model.

In panel data models like time series models, it is necessary to check the stationarity of the variables before estimation. Spurious regression is created by non-stationary variables. Therefore, the application of the unit root test will be essential to ensure the validity of the results. There are a variety of panel unit root tests, including Levin et al. (2002), Im et al. (2003), Fisher tests (Maddala & Wu 1999; Choi, 2001), and Hadri test (2000). The tests of Levin et al. (2002) and Im et al. (2003) are more popular. Levin et al. (2002)'s panel unit root test assumes a homogeneous autoregressive coefficient for all members of the panel, whereas Im et al. (2003)'s test allows for a heterogeneous autoregressive coefficient. In other words, the former has a common unit root process and the latter has an individual unit root process. The results of Im et al. (2003)'s unit root test are misguided when the length of the time period is small for each section (Pierse & Shell, 1995). In our study, the stationarity of the variables is examined by Levin et al. (2002)'s test.

Consider the following simple econometric model, which will be the basis of our analysis:

$$y_{it} = \alpha + x'_{it}\beta + u_i + \varepsilon_{it} \qquad (3)$$

in which Y_{it} is the dependent variable, X_{it} is the instrumental variable, ε_{it} is the traditional error of the country *i* in the period *t*, u_i is the individual or time-specific error (unobserved heterogeneity among countries or time periods), and α is the intercept.

There are different methods to estimate panel data. If there is no unobserved heterogeneity among countries or time periods, the least-squares panel data method is used. Otherwise, there are different estimation methods based on heterogeneity with fixed or random effects. The fixed and random effects models are defined as (Park, 2011):

$$FE: Y_{it} = (\alpha + u_i) + X'_{it}\beta + \varepsilon_{it}$$
$$RE: Y_{it} = \alpha + X'_{it}\beta + (u_i + \varepsilon_{it}) \qquad (4)$$

The unobserved heterogeneity, which is the omitted variable, is a part of the intercept in the fixed effect model. In other words, the fixed effects model studies different intercepts of the countries or time periods. But, it is a part of the error term in the random effects model. There are two components of the error term, traditional error (ε_{it}) and specific error (u_i), in this model. Therefore, assumption $\text{cov}(X_{it},u_i)=0$ is necessary in the random effects model. Otherwise, the random effects estimators will be inconsistent. Also, the random effects model studies the difference in error variance (Park, 2011).

Endogeneity, which is one of the serious problems in patterns econometric, is defined as: $\text{cov}(X_{it}, \varepsilon_{it}) \neq 0$. It is a source of the inconsistency of the least-squares estimators (Baltagi, 2005). Thus, endogeneity is controlled by instrumental variables. Within the panel data framework, instrumental variables are necessary for preventing simultaneously. There are three methods to use instrumental variables: a) instrumental variables method (IV), b) the Hausman-Taylor method, and c) the Arellano-Bond (1991), which is first-differencing Generalized Method of Moments (GMM).

The Arellano-Bond method is used while the lagged value of the dependent variable is as an explanatory variable in the model. Time-invariant variables are estimated in the Hausman-Taylor method. There are two groups of variables in this method, time-variant and time-invariant variables. Also, some explanatory variables are correlated with the component of individual effects, and others are not correlated in this method. Therefore, IV method is used due to more restrictions in the Hausman-Taylor method (Cameron & Trivedi, 2009).

Individual fixed effects and the least-squares panel data methods are compared with F-test and fixed effects and random effects with the Hausman specification test. The Hausman specification test is defined as follows (Green, 2008):

$$LM = (b_{fe} - b_{re})\hat{W}^{-1}(b_{fe} - b_{re}) \approx \chi^2(k) \qquad (5)$$
$$\hat{W} = Var(b_{fe} - b_{re}) = Var(b_{fe}) - Var(b_{re})$$
$$H_0 : \text{cov}(\alpha_i, x_{it}) = 0$$

If the null hypothesis is refuted, the fixed effects model is then preferred. Otherwise, the random effects model is appropriate.

3. Results and Discussion

In panel data econometrics, the initial step involves determining whether there is cross-sectional dependence or independence prior to conducting any tests. To assess cross-sectional dependence, Pesaran's (2004) CD test was employed. The estimation outcomes of this test indicate that the null hypothesis, which suggests no cross-sectional dependence at the one percent significance level for all variables and across the five groups of countries (Developed countries (G1), High-income developing countries (G2), Upper middle-income developing countries (G3), Lower middle-income developing countries (G4), Low-income developing countries (G5)), is rejected (Table 1). The list of the studied countries by different groups is provided in Appendix.Consequently, conventional tests and the first generation of unit root analysis cannot be applied in panel data analysis, necessitating the use of specialized tests that account for this cross-sectional dependence.

Table 1. Cross-sectional dependence test results (CD-test statistic)

Variabels	**G1**	**G2**	**G3**	**G4**	**G5**
Log(G)$_{-1}$	36.2***	8.62***	16.08***	4.39***	26.63***
Log(POPDEN)	152.02***	37.58***	21.58***	38.41***	89.82***
Log(EN)	21.13***	29.18***	5.02***	8.12***	17.32***
Log(OPEN)	63.19***	75.03***	125.12***	19.49***	87.03***
(RL)	2.35***	22.78***	9.92***	37.26***	4.28***
(CO)	7.82***	9.32***	52.55***	6.37***	18 ***
(DEMO)	11.09***	73.14***	48.25***	16.19***	88.71***

*** p<0.

Source: Research finding

Due to the presence of cross-sectional dependence, the unit root of the Pesaran (2007) test, also known as the cross-sectional augmented IPS test, was used. As seen from Table 2, the result showed that all variables for all country groups were stationary (I(0)).

Table 2. Panel unit root test results

Variabels	**G1**	**G2**	**G3**	**G4**	**G5**
Log(G)$_{-1}$	-1.84**	-2.16***	-1.69*	-3.12***	-2.23***
Log(POPDEN)	-3.45***	-5.61***	-2.21***	-6.82***	-4.03***
Log(EN)	-2.15***	-2.89***	-2.15***	-3.02***	-2.15***
Log(OPEN)	-1.78**	-1.98***	-1.98***	-2.23***	-1.69*
(RL)	-4.52***	-6.05***	-3.81***	-3.62***	-4.92***
(CO)	-1.68*	-2.48***	-2.09***	-1.93***	-2.63 ***
(DEMO)	-5.64***	-8.02***	-5.03***	-6.88***	-3.48***

*p<0.1, ** p<0.05 and *** p<0.

Source: Research finding

If cross-sectional dependence exists, it is recommended to use the Westerlund (2007) cointegration test to test for the presence of long-run relationships between variables. Westerlund's (2007) test with four panel cointegration statistics (P_r, Pα, G_r, Gα) examines the long-run relationship between variables. In this context, four sets of test statistics for five groups of countries are reported in

Table 3. The results of Westerlund's (2007) cointegration test show that the non-cointegration hypothesis is rejected at the 1% level for all four statistics. Thus, the long-run steady-state relationship between the variables is confirmed.

Table 3. Panel cointegration test results

Variabels	G1	G2	G3	G4	G5
P_r	-4.58***	-7.23***	-11.02***	-14.51***	-21.08***
$P\alpha$	-9.28***	-6.47***	-6.42***	-7.2***	-5.13***
G_r	-5.15***	-15.31***	-8.74***	-8.24***	-4.37***
$G\alpha$	-15.65***	-4.62***	-4.24***	-6.08***	-3.81***

*** p<0.

Source: Research finding

The estimation was done by the instrumental variables method (IV) because the lagged value of the log real income per capita is an endogeneity variable (Aşıcı, 2012). Table 4 reports the results of the F and Hausman specification tests revealing that the fixed effects model is preferred to the pooled panel regression and random effects for all country groups.

Table 4. F-Test and Hausman Specification Test

Classification of countries	F -statistic	Hausman specification statistic
Developed countries	278.4***	69.55***
High-income developing countries	27.51***	33.3***
Upper middle-income developing countries	189.79***	43.3***
Lower middle-income developing countries	375.76***	15.48**
Low-income developing countries	29.21***	22.71***

** p<0.05 and *** p<0.

Source: Research finding

Initially, robustness checks were used to validate the results. For this purpose, to investigate the effect of economic growth on the environment of the studied countries, the model was estimated with only the explanatory variable of real per capita income ($G_{i,t-1}$), the results of which are shown in Table 5. Table 5 shows that economic growth has a positive and significant effect on pressure on nature. Then, the model was estimated by countries based on the criteria of development and income (Table 6). Because it is rational to expect that the impact of income growth on the environment in high-income countries will be different from low- and middle-income countries (Aşıcı, 2012; Destek & Sinha, 2020). The results of Table 3 show that for low- and middle-income developing countries, economic growth increases the pressure on nature. But for high-income developing countries, this effect is not significant, and for developed countries, the effect of economic growth on the pressure on nature is negative and significant. Finally, the effect of economic growth on the pressure on nature was evaluated according to the criteria used in the ANS index (Table 7). The results of Table 4 showed that economic growth has a positive and significant effect on the three components of CO2 degradation, mineral, and energy depletion, but the effect of this variable on the component of net forest reduction is not statistically significant.

Table 5. Robustness check: all of countries (balanced panel)

Variables	All of counteries
$Log(G)_{-1}$	0.82^{***}
α	-2.32^{***}

Source: Research finding

Table 6. Robustness check: different countries group

Variables	Developed	High-income developing	Upper middle-income developing	Lower middle-income developing	Low-income developing
$Log(G)_{-1}$	-0.03^{***}	1.46	2.11^{***}	3.08^{***}	3.23^{***}
α	10.83^{***}	8.26^{***}	-9.53^{***}	-16.21^{***}	-18.54^{***}

Source: Research finding

Table 7. Robustness check: components of pressure on nature

Variables	CDD	MD	ED	NFD
$Log(G)_{-1}$	0.63^{***}	0.38^{**}	0.49^{**}	0.08
α	-6.48^{***}	-7.56^{***}	-7.53^{***}	-12.38^{***}

Source: Research finding

The results of the diagnostic tests also show that the estimated linear model satisfies the conditions of data normality, absence of serial correlation and conditional heterogeneity (see Table 8).

Table 8. The results of diagnostic tests

Diagnostic tests	G1	G2	G3	G4	G5
JB test	0.386	3.44	0.983	2.18	4.12
	(0.852)	(0.145)	(0.523)	(0.248)	(0.112)
LM test	0.582	0.780	1.52	1.89	0.653
	(0.352)	(0.308)	(0.145)	(0.110)	(0.327)
ARCH test	0.418	1.28	0.765	2.93	1.15
	(0.538)	(0.172)	(0.502)	(0.123)	(0.179)

1. The value in parenthesis is p values.
2. JB is Jarque–Bera normality test.
3. LM is Lagrange multiplier test for serial correlation.
4. ARCH is Heteroscedasticity test.

Source: Research finding

In the estimated model, the probability of the Sargan test statistic is equal to 0.57, so the null hypothesis that there is no correlation between the instruments and the error terms cannot be rejected (see Table 9). Therefore, the results indicate the appropriate selection of the instrumental variables used in this model, as well as confirming their selection and validity.

Table 9. Validity test of instrumental variables

Statistis	Prob
Sargan test (Chi2)=9.68	0.572

Source: Research finding

Finally, the results of the effect of all the explanatory variables on the ANS index by groups of different countries are presented in Table 10. Table 10 reports the results of the fixed effects IV method and it should be noted that some variables were excluded due to time invariant. The results of the Wald test represents an appropriate estimation for all country groups.

The results in Table 10 indicate that the relationship between the income per capita and pressure on nature per capita is negative and very poor for developed countries so that the pressure on nature p.c. will decrease by 0.001% with a 10% increase in per capita income. Therefore, a negative relationship between per capita income and per capita environmental pressure is justifiable in developed countries (Boulatoff & Jenkins, 2010). But, this relationship is positive and significant in all developing countries, yet the effect is much stronger in low-income than in high-income countries. These findings are almost consistent with Muradian and Martinez (2001), Aşıcı (2012), and Ganda (2019b). They concluded that the relationship between growth and damage of nature is not significant in high-income countries and significant and positive in low-income countries. Therefore, it is found that economic growth in developed countries tends to increase the consumption of resources that come from developing countries. On the other hand, according to the EKC analysis, the countries seek to improve their environmental conditions after achieving a desirable level of economic growth and development. This finding is in line with Wang et al. (2013), Aşıcı & Acar (2018), Ulucak & Bilgili (2018) studies and contradicts Charfeddine and Mrabet (2017) and Destek and Sinha (2020) studies. The income coefficient of low-income developing countries is 2.03. Thus, the pressure on nature p.c. will increase by 20.3% with a 10% increase in per capita income. Therefore, the development pattern of developing countries is unsustainable, unlike developed countries.

According to the results in Table 10, an increase in global trade or trade liberalization raises environmental pressure significantly for all groups of countries except for lower middle-income developing countries. This result has been confirmed in Aşıcı (2012) and Charfeddine (2017) studies and contradicts the finding of Destek and Sinha's (2020) study. The effect of this variable is stronger in low-income countries than in the other groups so that a 10% increase in the trade liberalization is associated with a 14.9% increase in per capita pressure on nature.

Table 10. Fixed Effects IV Coefficients

Variables	Developed	High-income developing	Upper middle-income developing	Lower middle-income developing	Low-income developing
$Log(G)_{-1}$	-0.0001***	1.37***	1.74***	1.83***	2.03***
	(0.00004)	(0.25)	(0.18)	(0.34)	(0.41)
Log(POPDEN)	0.00007	0.71	4.53***	4.45***	3.44*
	(0.00006)	(0.48)	(0.87)	(0.57)	(1.82)
Log(EN)	-1.38***	-2.44***	0.0002	0.22	0.6
	(0.15)	(0.36)	(0.0004)	(0.63)	(0.95)
Log(OPEN)	1.27***	1.28***	0.83***	0.21	1.49***
	(0.30)	(0.21)	(0.14)	(0.16)	(0.53)
(RL)	------	-0.4**	------	-0.77***	-0.88*
		(0.21)		(0.24)	(0.47)
(CO)	0.08***	0.07***	0.017	-0.17***	-----
	(0.02)	(0.02)	(0.01)	(0.05)	
(DEMO)	-----	0.13	0.007	-0.08***	----
		(0.09)	(0.005)	(0.01)	
α	9.49***	5.73**	-6.22***	-13.22***	-15.93***
Wald	217.77***	266667.24***	696925.92***	744496.58***	65217.86***
R^2	0.432	0.563	0.345	0.504	0.481

*, ** and *** represent significant at 10%, 5% and 1%
The values in parentheses indicate the standard error.
Source: Research finding

The results of the analysis indicate that improving the structure of rules and standards will promote environmental conditions. The coefficient of rules quality variable is negative and significant in different income groups of developing countries. This coefficient is greater in low-income developing countries than the other groups so that 1 unit increase in the rules quality index is associated with a 0.88% reduction in the per capita pressure on nature. The result of this study shows that the effects of trade liberalization and standard quality on environmental pressure are in conflict with one another. This finding is in line with Al-Mulali et al. (2015) and Al-Mulali et al. (2016) studies and contradicts the findings of Destek and Sinha's (2020) study. Some researchers believe that the effect of rules and standards quality is in conflict with trade liberalization. According to Tisdell (2001) and Esty (2001), the presence of environmental and social limitations leads to institutions like the WTO violating regulations. Similarly, Daly (1993) contends that unrestricted trade fosters competition, which in turn leads to a decline in environmental standards and regulations. However, Steininger (1994) presents findings indicating that free trade in Mexico adversely affects the quality of regulations in border regions.

The relationship between capital openness and environmental pressure is positive and significant in developed and high-income developing countries so that 1 unit increase in the capital openness index is associated with a 0.08% and 0.07% increase in the per capita pressure on the nature of developed and developing with high-income countries, respectively. But, this effect is insignificant or even negative in developing countries with lower incomes. This can be attributed to the fact that capital openness in developed and high-income developing countries lead to the outflow of capital and the reduction of environmental investment (Aşıcı, 2012). This result is different in developing countries with lower incomes.

In democratic societies, it is anticipated that alleviating the strain on the environment will be achieved through increased governmental accountability towards environmental protection. Hence, it is crucial to consider the democracy index. However, the findings in this area do not consistently align. For instance, Knight and Rosa (2011) demonstrated that democracy does not have a significant impact on life satisfaction (well-being). York et al. (2003) and Marquart-Pyatt (2010) indicate that the relationship between democracy and the environmental index is either non-significant or positive. In this study, the influence of the democracy index on environmental pressure remains uncertain. This finding is in line with result of Knight and Rosa (2011) study. This effect is significant only in lower middle-income developing countries so that 1 unit increase in the democracy index is associated with a 0.08% reduction in per capita pressure on nature in lower middle-income developing countries. In other words, the democracy index improves environmental conditions. This finding contradicts the findings of Roeland and Soysa (2021) study.

Population density has an adverse effect on the environment in developing countries with lower incomes. This finding However, such a relationship was not established in developed or high-income developing countries. A 10% increase in population density increases the pressure on nature in upper middle-income, lower middle-income, and low-income developing countries by 45.3%, 44.5%, and 34.4%, respectively. This result shows that developing societies rely on natural resources to meet the needs of the population to a greater extent than developed countries. Therefore, developed nations have a more appropriate consumption culture than developing societies.

The coefficient of the school enrollment rate has a significant and negative effect in developed and high-income developing countries. A 10% increase in the school enrollment rate reduces the environmental pressure of developed and high-income developing countries by 13.8% and 24.4%, respectively. However, this variable is not significant in developing countries with lower incomes. Hence, it can be said that the education quality of developed and high-income developing countries is appropriate in the field of the environment.

4. Conclusion

The current study utilizes a comprehensive and suitable index, which combines CO_2 damage, mineral depletion, energy depletion, net forest depletion, and classifies countries into different income groups. Panel data is employed to account for the endogeneity of explanatory variables and estimate the actual impact of per capita income and other variables on environmental pressure. By selecting an appropriate estimation method, the study effectively captures the real effect of economic growth on environmental pressure, considering the endogenous nature of certain explanatory variables, including real per capita income. The initial robustness checks confirm the validity of the relationship between economic growth and pressure on the environment. Across 213 countries, there is a positive and significant association between economic growth and environmental pressure. This implies that as the global economy expands, the burden on nature increases, necessitating global agreements to address this situation. The findings indicate that in developing countries, there is a positive correlation between income per capita and per capita pressure on nature. However, this effect is more pronounced in low-income countries compared to high-income countries, likely because developed nations have adopted more sustainable alternatives to non-renewable resources while developing countries heavily rely on resource consumption. The study highlights the importance of developing countries shifting towards alternative resources instead of degrading non-renewable natural resources for growth and development. Additionally, it reveals that economic growth contributes to CO_2 emissions, mineral and energy depletion, but its impact on net forest depletion is not statistically significant. This suggests that countries worldwide have utilized energy and mineral resources, leading to carbon dioxide pollution during their economic development process. To improve the environment, there is a need to transition towards renewable and clean resources. Furthermore, the study finds that increased global trade intensifies environmental pressure. The quality of institutions, as measured by the enforceability of the rule of law, has a positive effect on the environment. It is recommended that developing countries enhance their legal frameworks, making them more coherent and efficient, while reducing bureaucratic complexity. In developed and high-income developing countries, an increase in school enrollment rates can influence the environment, but this effect is not significant in lower-income groups. This suggests that the educational systems of developing countries have limited emphasis on environmental topics. Consequently, governments should consider reforms to incorporate environmental education into the current system. In conclusion, population control in developing countries is associated with a positive impact on environmental quality.

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Appendix: The list of studied countries by different groups

Developed		**High-income developing**	
Australia	Latvia	American Samoa	Israel
Austria	Lithuania	Andorra	Korea, Rep.
Belgium	Luxembourg	Antigua and Barbuda	Kuwait
Canada	Malta	Aruba	Liechtenstein
Croatia	Netherlands	Bahamas, The	Macao SAR, China
Cyprus	New Zealand	Bahrain	Monaco
Czech Republic	Norway	Barbados	Nauru
Denmark	Poland	Bermuda	New Caledonia
Estonia	Portugal	British Virgin Islands	Northern Mariana Islands
Finland	Romania	Brunei Darussalam	Oman
France	Slovakia	Cayman Islands	Panama
Germany	Slovenia	Channel Islands	Puerto Rico
Greece	Spain	Chile	Qatar
Hungary	Sweden	Curaçao	San Marino
iceland	Switzerland	Faroe Islands	Saudi Arabia
Ireland	ulgaria	French Polynesia	Seychelles
Italy	United Kingdom	Gibraltar	Singapore
Japan	United States	Greenland	Sint Maarten (Dutch part)
		Guam	Trinidad and Tobago
		Guyana	United Arab Emirates
		Hong Kong SAR, China	Virgin Islands (U.S.)
		Isle of Man	

Upper middle-income developing		Lower middle-income developing		Low-income developing
A]lbania	Kazakhstan	Angola	Lesotho	Afghanistan
Argentina	Kosovo	Algeria	Mauritania	Burkina Faso
Armenia	Libya	Bangladesh	Micronesia, Fed. Sts.	Burundi
Azerbaijan	Malaysia	Benin	Mongolia	Central African Republic
Belarus	Maldives	Bhutan	Morocco	Chad
Belize	Marshall Islands	Bolivia	Myanmar	Congo, Dem. Rep
Bosnia and Herzegovina	Mauritius	Cabo Verde	Nepal	Eritrea
Botswana	Mexico	Cambodia	Nicaragua	Ethiopia
Brazil	Moldova	Cameroon	Nigeria	Gambia, The
Bulgaria	Montenegro	Comoros	Pakistan	Guinea-Bissau
China	Namibia	Congo, Rep.	Papua New Guinea	Korea, Dem. People's Rep
Colombia	North Macedonia	Côte d'Ivoire	Philippines	Liberia
Costa Rica	Palau	Djibouti	Samoa	Madagascar
Cuba	Paraguay	Egypt, Arab Rep.	São Tomé and Principe	Malawi
Dominica	Peru	Eswatini	Senegal	Mali
Dominican Republic	Russian Federation	Ghana	Solomon Islands	Mozambique
El Salvador	Serbia	Guinea	Sri Lanka	Niger
Equatorial Guinea	South Africa	Haiti	Tanzania	Rwanda
Ecuador	St. Lucia	Honduras	Tajikistan	Sierra Leone
Fiji	St. Vincent and the Grenadines	Jordan	Timor-Leste	Somalia
Gabon	Suriname	India	Tunisia	South Sudan
Georgia	Thailand	Iran, Islamic Rep	Ukraine	Sudan
Grenada	Tonga	Kenya	Uzbekistan	Syrian Arab Republic
Guatemala	Türkiye	Kiribati	Vanuatu	Togo
Indonesia	Turkmenistan	Kyrgyz Republic	Vietnam	Uganda
Iraq	Tuvalu	Lao PDR	Zambia	Yemen, Rep.
Jamaica	West Bank and Gaza	Lebanon	Zimbabwe	