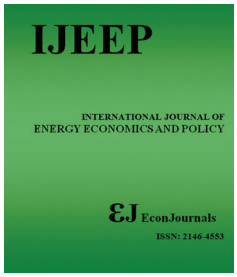


International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(5), 311-320.

On the Way to Net Zero Emissions: Can Environmental Tax be the Game Changer? The Vise Grad Group Evidence

Takyi Kwabena Nsiah[1]*, Martin Mikeska[1], Beata Govurova[2]

[1]Department of Applied Economics, Faculty of Management and Economics, Tomas Bata University in Zlin, Mostni 5139, 76001 Zlin, Czech Republic. [2]Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Kosice, Letna 9, 042 00 Kosice, Slovak Republic.*Email: takyi@utb.cz

Received: 19 March 2024 **Accepted:** 30 July 2024 **DOI:** https://doi.org/10.32479/ijeep.16056

ABSTRACT

Today, protecting the environment is a top issue for global policy. In essence, the literature has identified several macroeconomic problems as factors in environmental deterioration. The purpose of the investigation was to explore environmental deterioration (EVD) and energy consumption (ENC) by Vise grad regions. Environmental taxes (ENTX) and carbon taxes have been proving to be a significant factor in carbon mitigation. The analysis was carried out for the period 1994-2021, employing the fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS). The empirical evaluation indicates that ENC had a positive while ENTX had a negative nexus with EVD for the Vise grad nations. Similarly, the moderating role of ENTX*ENC – EVD exhibited an inverse affiliation. In the long run, the dependence on non-renewable energy appreciates EVD. However, effective policy implementation of ENTX will lead to quality of the environment. The empirical results have shown that ENTX can be employed to control the demand and utilization of coal, gas, and nuclear in the Vise grad regions. This research offers policymakers and government organizations in these areas a reference point for their investments in more eco-friendly technology, human capital, urbanization, trade openness, and appropriate environmental levies to demonstrate the quality of the environment.

Keywords: Environmental Deterioration, Environmental Tax, Energy Consumption, Vise Grad Regions.
JEL Classifications: O13, Q50, Q54

1. INTRODUCTION

The awareness of ecological destruction in the form air pollution, water and deforestation has caused government and institutions to put measures to reduce this catalyst. Industrial expansion and uncontrollable population increase have cause increase in the emission of harmful gases into the environment (Boukar et al., 2024; Huseynli, 2024; Kusiyah et al., 2024). Energy consumption (coal, gas, and oil) and economic progress has been the cause of an increase in environmental deterioration. Literary has shown that there are factors accounting for increase in environmental depreciation (Anwar and Elfaki, 2021) economic progress, energy consumption, and trade openness (Omoke et al., 2022) financial development and trade openness (Latief et al., 2022; Rehman et al., 2022; Yasin et al., 2021) urbanization and tourism development. The Vise grad group or V4 Nations (Poland, Hungary, Slovakia, and Czech) are among the top consumption on non-renewable energy in the EU regions. By 2030, the European Green Deal seeks to cut greenhouse gas emissions by 55%, and by 2050, it seeks to achieve complete climate neutrality. With $40.3 billion in recompensed aid and a total of $164.3 billion in grants from the EU budget for 2021-2027, Poland is the member state that receives the most funding from the EU compared to all others. Hungary and Poland have yet to formally ratify their respective agreements with the EU Commission. Environmental taxes have become a significant factor in reducing the emission of gases in the environment. In the context of OECD communities, Zhang and Chen, (2023) delved on the affiliation between clean tax and how it can mitigate emissions. The quantile approach depicted that clean tax had a favorable two-way direction. Likewise, Meng

and Yu, (2023) examined tax policies in China on high power energy enterprises. The article's findings illustrated that raising taxes prices helps firms to shift to renewable energy resulting in depreciation in their carbon footprint. Among the E seven economics, (Yunzhao, 2022) modeled an investigated into carbon emissions reduction. The empirical results show that innovation and taxes on environmental deterioration had a material affiliation to reduced environmental depletions.

Furthermore, Vise grad group recently decades have seen increased in urban developments of transportation and household consumption on coal and fossils fuels. As there is free movement of goods and services, environmental depletion is also transferred. From a global point of view of urbanization, (Chen et al., 2023) examined a panel of 125 communities with a robustness econometric model. The empirical evaluation established a U shape from developing to developed economics with high service actives in smart urban localities. Employing the STIRPAT approached in provinces of China, (Yu et al., 2023) investigated urban carbon. They identified 1% appreciation in population corroborated with a 3.2% in ecological deterioration. However, Liu et al., (2023) investigation in China demonstrated that urbanization had no material cause in the emissions appreciation. The vise grad communities have seen a rise in their population causing an increase in urban deterioration. According to the EU report (2022) the trade volume in the four countries has tripled.

Previous scholars have linked the EVD-ENC investigation to the Environmental Kuznets Curve concept (EKC). This replica demonstrates the fishhook-like relationship that exists between environmental degradation, energy use, and economic progress. According to the explanation of the idea, a rise in environmental deterioration will follow a rise in economic advancement. The immediate effects of pollution have, however, been mitigated over time (Chukwudi Udeagha and Ngepah, 2022; Khan et al., 2022). Again, research on economic progress, energy used, and environmental deterioration has presented significant factors that can influence these links. Factors such as openness to trade (TRO), human capital (HUC), and urbanization (UBR) (Anwar and Elfaki, 2021; Hussain et al., 2022; Liu et al., 2021). Therefore, the current research will give governments, businesses, and policymakers answers and recommendations for EVD decision-making and policy creation. This inquiry will add to the knowledge of the linkage between ENC, ECP, and EVD in Vise grad economics. In addition, the study's analysis of the nexus between ENTX and EVD in the V4 nations is innovative. The affiliation between ENC and EVD was moderated by ENTX. Theoretically, the research affirms to the EKC assumption on the concept of energy use, economic development, and environmental degradation. With respect to the methodological contribution, the researchers adopted the FMOLS and DOLS for the analysis and the affiliation among the indicators. The Westerlund and Koa cointegration was employed for with unite roots tests for stationarity. From the above results and the situation of the Vise grad communities, this investigation seeks to explore; (1) How do ECP, ENC, and ENTX affect environmental degradation in V4 economies? (2) How are the specified study variables related causally? (3) What policy changes are necessary to address the greater EVD in the V4 regions? (4) What is ENTX's moderating impact on the EVD-ENC nexus?

The other sections of the research are organized as follows: Section 2 summarizes the relevant literature; Section 3 presents the technique design for the study using an econometric model; and Section 4 contains empirical analysis and observations. This paper offers theoretical and policy recommendations at the end.

2. LITERATURE REVIEW

The use of non-renewable energy is strongly linked to the acceleration of climate change. Environmentalists and economists have suggested vital renewable energy alternatives that will decrease the effects of using fossil fuels. Li (2020) conducted a study on the effects of ENC, GDP growth, and carbon emissions from 1992 to 2014 among the G-20 States. The compendium found, through data analysis using the CCEMG and AMG models, that both ENC and GDP growth increase carbon emissions. The affiliation between energy use, environmental pollution, and economic development was investigated in South Asian communities. The article's conclusion was that increased energy use and economic growth were contributing to a worsening of the ecological situation (Mughal et al., 2022). According to a study conducted on 51 countries Chaabouni and Saidi, (2017), economic development and carbon emissions are affiliated in both directions. According to Munir and Riaz (2020), the NARDL model was used to examine the effects of oil, gas, and coal usage between 1975 and 2018 in most industrialized economies, including the USA, Australia, and China. Their findings indicate that when energy use rises, so do these regions' carbon emissions. Pata (2021) looked at the nexus between economic complexity, energy use, and ecological footprint in the USA from 1980 to 2016 to further the theoretical underpinnings of the KKC hypothesis. A fishhook shaped EKC association between ECP and EVD was demonstrated, according to the summary. According to the inquiry studies mentioned above, energy consumption contributes to economic growth. However, rising fossil fuel use degrades the environment's quality (Bajja et al., 2024; Saqib et al., 2024; Shan et al., 2024; Xiao et al., 2023).

Again, governments and environmental institutions have suggested different environmental fees and taxes as a measure of control as climate change and environmental deterioration concerns worsen. The buoyancy of environmental taxes in the short- and long-term was examined employing data from 28 EU territories from 2000 to 2018. According to the panel data study, (De Pascale et al., 2021) illustrated that tax rigidity was successful for a limited time, but positive policy impacts were achieved in the transportation sector. Similarly, Esen et al. (2021) investigation on the impact of environmental taxes in the EU used the PSTR model to choose 15 States between 1995 and 2016 and found that the effective environmental taxes in these areas greatly reduced environmental pollution. Additionally, using the MMQR and Dumitrescu and Hurlin models, (Xie and Jamaani, 2022) analyzes ENTX and CO2 of a set of G-7 countries between 1990 and 2020. The analytical findings support how important environmental fees are in reducing carbon emissions. (Lin and Jia, 2019) looked on the tax structure

Figure 1: Emissions trend study for the V-4 nations using CO_2

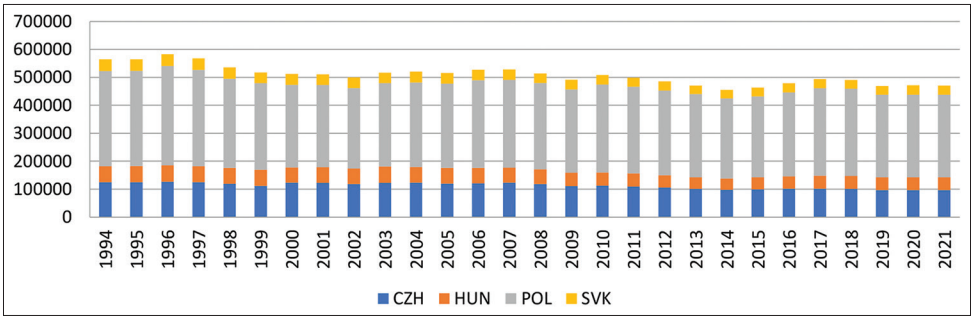


Figure 2: Examining the general trend of GDP growth among the V-4 nations

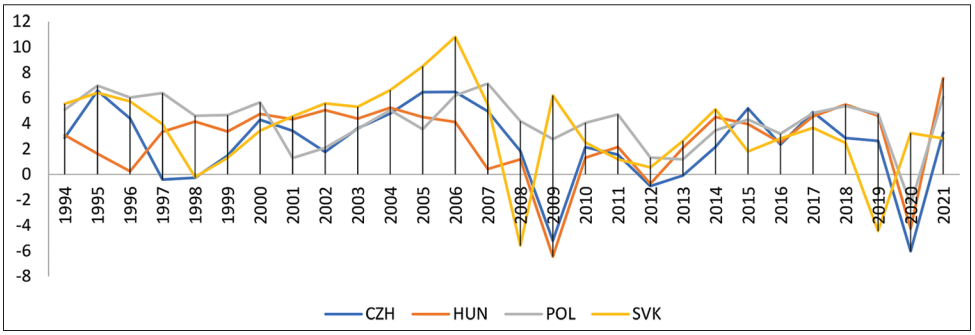


Figure 3: Examination of environmental tax trends among the V-4 nations.

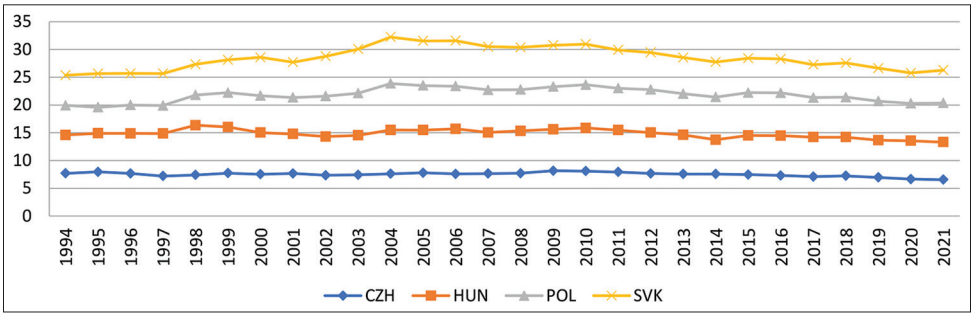
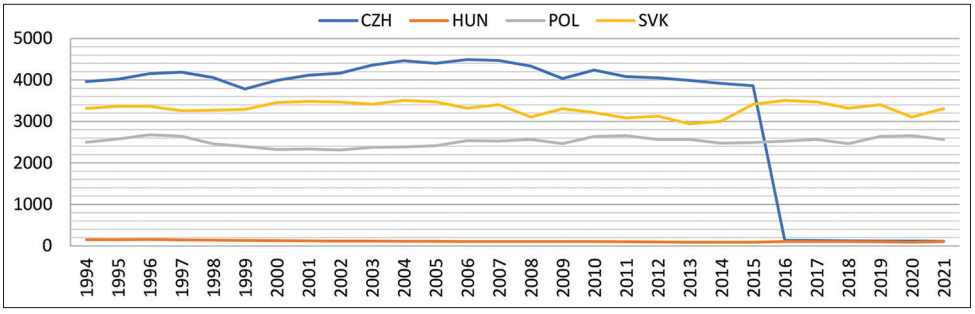


Figure 4: The V-4 nations' energy consumption trend study



for energy-using businesses in China. Their research using the CGE reveals that changing the tax policy design and the rate to pay has a positive impact on the amount of energy utilized. testing the effect of environmental taxes in China using the same CGE model. According to Lin and Jia (2019) research, high energy consumption companies' ecological pollution is decreased by an appropriate tax policy. On the other hand, this has a negative effect on economic progress. Literary evaluation on the nexus between ENC and EVD illustrates that ENTX might be a useful tool in the fight against environmental deterioration (Doğan et al., 2022a; Tan et al., 2022; Wang and Yu, 2021).

Between 2000 and 2019, examining the role of education, (Xiao et al., 2023) conducted investigation on 125 country analysis to understand how the educational attainment of a population influences carbon emissions. The study found a U shape affiliation. Focusing on industrial sectors, (Umar et al., 2022) investigated the impact of skilled labor on carbon emissions in 5740 manufacturing enterprises.

Their findings indicated a negative nexus, depicting that industries with a higher proportion of skilled workers tend to exhibit lower carbon emissions. Considering the role of knowledge-intensive industries within the MENA economics, (Bajja et al., 2024) explored how the concentration of knowledge workers influences carbon emissions at the regional level. The study found that regions with a higher concentration of knowledge workers tended to have lower carbon emissions, attributing this to a greater focus on sustainable practices and innovation in these areas. Focusing on the affiliation between human capital and carbon emissions in the context of urbanization, (Shan et al., 2024) found that BRICS with higher levels of education and skilled labor tended to have lower carbon emissions per capita. Saqib et al., (2024) looked at ICT in top polluting economics between the year 1993 and 2020. The empirical evaluation illustrated that HUC had a bidirectional link with carbon emission.

Sun et al. (2022) conducted study on the impact of urbanization and renewable energy on carbon emissions in the MENA areas between 1991 and 2019. According to the analysis's findings, carbon emissions in MENA areas are brought on by rising urbanization and economic development., Grodzicki and Jankiewicz (2022) investigate how urbanization and renewable energy use affect C02 emissions in Europe. Using the spatiotemporal model and the 1995–2018 data period, the results indicate that urbanization and carbon emissions are leading to a fall in Eastern Europe and an increase in North Europe. (Li et al., 2021) used the cross-sectional ADRL for 1990-2020 to investigate the affiliation between urbanization and environmental degradation. The investigation's findings imply that the growth in environmental contamination has a direct, positive relationship with urbanization. Musah et al. (2022) analyzed G twenty low-middle economics from 1992 to 2018 by examining the pollution model. According to the paper, the G-20 States' urbanization was a major contributor to carbon emissions. In Westb Africa, Musah et al., (2021) employed a panel study to explore the nexus between urbanization and CO_2 emissions. The econometric evaluation exhibits a material affiliation between urbanization and emissions.

Trade openness is the unrestricted flow of products between countries. It is believed that trade openness causes economic growth, employment, and poverty alleviation. As a country's industry grows, so does its institutions' energy usage. According to (Udeagha and Ngepah, 2022), TRO might manifest as the size effect, the composition impact, and the technical effect. Kwamena Tachie et al., (2020) examined the TRO of 18 EU countries. Results demonstrate that trade liberalization increases carbon emissions. Likewise, within Asian Wenlong et al., (2023) delved trade openness impact on environmental deterioration. They identified TRO as a catalyst in the Asian environmental depreciation. With trade inflow increased in emerging communities, Suleman et al., (2024) concentrated on its influence on emission between 1995 and 2020. The article's empirical illustration demonstrated that not only do TRO appreciate economic progress but immaterially degrade the ecosystem.

2.1. Gaps in Literary Work

The current research examines the impact of economic progress, energy consumption, urbanization, trade openness, human capital, and environmental taxes in addressing environmental deterioration. Previous studies have also explored this relationship, but they exhibit certain deficiencies. This study addresses these gaps by incorporating additional insights. Firstly, previous literature has presented conflicting views on the affiliation between economic progress, energy consumption, urbanization, trade openness, human capital, and environmental taxes. However, this study clarifies this nexus, demonstrating a material affiliation between economic progress, energy consumption, urbanization, trade openness, human capital, and environmental taxes on environmental deterioration. Again, the material effect of environmental tax as an interaction was investigated on energy consumption and environmental deterioration. Furthermore, while past research has analyzed the environmental consequences and the efficacy of economic progress, energy consumption, urbanization, trade openness, human capital, and environmental taxes in various countries, there is a dearth of research in Vise grad communities. By examining these factors in Vise grad communities, this investigation bridges this gap in literature. Additionally, previous studies have often focused on limited time frames and diverse methodologies when investigating the relationship between economic progress, energy consumption, urbanization, trade openness, human capital, and environmental taxes on mitigation of environmental deterioration. By extending the analysis period from 1994 to 2021, this study provides a comprehensive overview. Moreover, this research employs advanced econometric techniques such as FMOLS and DOLS to address issues like CSD, heteroskedasticity, and endogeneity, thus enhancing the reliability of the findings and contributing to the existing body of literature. The trend of the variables is illustrated in figures 1- 4 covering the data curation period.

3. METHODOLOGY

3.1. Theoretical Background

This research is based on the EKC hypothesis established by Grossman and Krueger in their 1995 essay "Economic development and the environment." In the early phases of ECP, nations required more energy for industrial expansion, as seen by the fishhook-shaped curve generated by the inquiry. As an economy grows and other areas improve, however, these impacts of pollution are reversed. Decades' worth of research has demonstrated that ECP has a immediate affiliation with EVD. Literary investigations have confirmed that there is a connection between ECP and ENC (Saqib et al., 2024; Shan et al., 2024; Xiao et al., 2023).

The evaluation findings support the expectation that there will be a favorable nexus between ECP, ENC, and EVD. Once again, environmental rules and regulations, such as ENTX, are utilized to reduce carbon emissions. With correctly implemented taxes on resource usage, the V4 nations will limit their consumption of nonrenewable energy sources such as gas, oil, coal, and fossil fuels. Observations from prior research indicate that environmental deterioration can be mitigated by environmental taxes. Investigations demonstrate a negative association between ENT and EVD (De Pascale et al., 2021; Esen et al., 2021). Consequently, this study analyzes human capital, urbanization, and trade openness as control constructs supporting the invested U-shaped EKC approach. This study modifies the effect of ENTX

on the relationship between EVD and ENC in the V4 nations. The theoretical framework chosen for this investigation is depicted in Figure 5.

3.2. Data Source

The data utilized to evaluate EVD, ENC, ECP, TRO and HUC were gathered from World Development Indicator (WDI, 2022), whereas the dataset for ENTX was obtained from the World Health Organization (OECD, 2022). All research parameters' descriptions and units of measurement are shown in Table 1. Figure 5 is a graphical representation of the parameters analyzed in this study for all V4 communities. The elaboration of the analysis employed the social science statistical instrument (EVIEWS).

Model definition.

$$END^{it} = \beta_0 + \beta_1 ENC^{it} + \beta_2 ECD^{it} + \beta_3 HUM^{it} + \beta_4 UBR^{it} + \beta_5 OPT^{it} + \mu^{it} \quad (1)$$

$$END^{it} = \beta_0 + \beta_1 ECD^{it} + \beta_2 ENTX^{it} + \beta_3 HUM^{it} + \beta_4 UBR^{it} + \beta_5 OPT^{it} + \mu^{it} \quad (2)$$

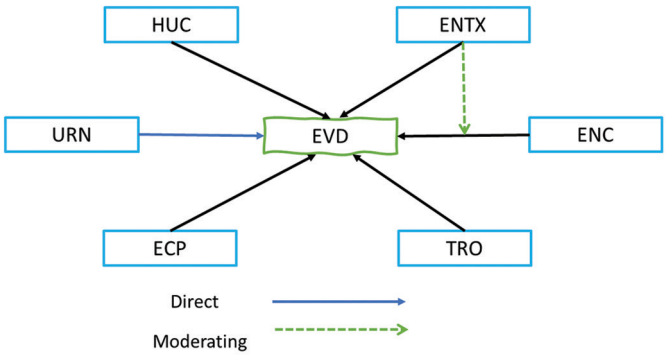
$$END^{it} = \beta_0 + \beta_1 ENC^{it} + \beta_2 ECD^{it} + \beta_3 ENTX^{it} + \beta_4 HUM^{it} + \beta_5 UBR^{it} + \beta_6 OPT^{it} + \beta_7 ENC * ENTX^{it} + \mu^{it} \quad (3)$$

4. EMPIRICAL ANALYSIS

4.1. Cross Sectional Dependence Test

It is said that cross-sectional dependency makes it difficult to calculate panel data (CSD). There may be inconsistencies and inefficiencies in the analyzed parameters due to the presence of CSD. Therefore, several indicators, such as conventional shocks, spatial implications, and overlooked country-specific elements, may be to blame for these challenges (Mohanty and Sethi, 2022). Likewise, it is essential to examine the CSD among the indicators as it helps to prevent unanticipated results. In this study, the CSD estimate created by(Breusch and Pagan, 1980) and (Chudik and Pesaran, 2015).

Figure 5: Theoretical framework



$$CSD\sqrt{\frac{2T}{N(N-1)}\sum_{i=1}^{N}\lambda_i\sum_{m=i+1}^{N}\psi_{im}} \quad (5)$$

i represents the affiliation Coeff of i and m units, and CSD is shown in the panel with N and T, which indicates the time. The outcome of the results implies that the Vise grad regions are interlinked. As a result, a shock in one region will affect the others. The outcome from table 2 demonstrated that all EVD, ENC, ECP, ENTX, HUC, URN, and TRO had no CSD presence in the dataset.

4.2. Panel Unite Root Test

After affirming no cross-sectional dependence among the variables, we employed the panel unit root developed by (Im et al., 2003; Levin et al., 2002) to check the level of the variables before any further evaluation was conducted. Table 3 showed that the variables were all at stationary at first different.

4.3. Cointegration

The Wester Lund panel cointegration testing method is used in this study to combat cross-sectional dependence and heterogeneity among extremely varied datasets from various nations, as shown in Table 6. The two sets of cointegration techniques offered by Wester Lund (2007) are displayed in Table 6, together with the appropriate two-panel statistics and probabilities. The results indicate that both categories (Gt and Ga) are materially significant, with a level of 1% being incredibly significant. However, these intriguing findings demonstrate long-term cointegration between the variables

Table 1: Synopsis of the variable description

Variable	E-views Code	Description	Source
Environmental Degradation	EVD	CO_2 emissions in kilo ton (kt)	WDI
Energy Consumption	ENC	Energy Usage (kg of oil equivalent per capita	WDI
Economic Growth	ECP	Per Capita (constant USD $2,010)	WDI
Human capital	HUC	Enrollment in primary education	WDI
Environmental Tax	ENTX	Millions of Euros	OECD
Urbanization	URN	Urban population (% of Total population	WDI
Trade Openness	TRO	Import and export (% of GDP)	WDI

Table 2: Cross-sectional dependency test

	Breusch-Pagan LM	Pesaran scale LM	Bias-correlated scale LM
EVD	58.810***	14.090***	14.016***
ENC	26.9221***	19.998***	19.924***
ECP	23.562***	10.028***	9.951***
ENTX	23.703***	3.9556***	3.882***
HUC	45.559***	15.705***	15.446***
URB	101.154***	26.314***	26.240***
TRO	136.412***	36.492***	36.417***
Ho: no cross-sectional dependence			

***1%, ** 5%, *10%

Table 3: Panel unit root

	LLC				Im, Pesaran, and W-stat			
	At level		1st difference		At level		1st difference	
	Statistics	P-value	Statistics	P-value	Statistics	P-value	Statistics	P-value
EVD	0.148	0.5589	−3.783	0.0001	1.232	0.8911	−3.982	0.0000
ENC	−0.246	0.4027	−3.726	0.0001	−0.247	0.4025	−4.527	0.0000
ECP	−1.849	0.0322	−5.815	0.0000	−1.863	0.0312	−5.304	0.0000
ENTX	−1.318	0.0938	−2.719	0.0033	−0.722	0.2351	−3.878	0.0001
HUC	−2.912	0.0018	−5.297	0.0000	−3.942	0.0000	−6.034	0.0000
URB	−2.013	0.0221	−5.983	0.0000	0.006	0.5024	−2.842	0.0021
TRO	−1.787	0.0369	−4.042	0.0000	−0.135	0.4461	−5.337	0.0000

All the variables are in log values

Table 4: Cointegration output

Kao residuals cointegration test		
	T-statistics	Prob
ADF	−2.964	0.015
Residual variance	0.006	
HAC variance	0.005	
Westerlund	Z-value	Prob
Gt	−7.542	0.000
Ga	0.654	0.387
Pt	−6.461	0.000
Gt	0.510	0.422

no cointegration with a significance level<1%. The null hypothesis is rejected

examined in this study. The results of Kao's co-integration also support a long-term co-integration between the chosen series.

4.4. Descriptive Analysis

Table 5 presented the synopsis of the descriptive outcome of the investigation, with EVD having a mean figure of 4.9571 and maximum at 5.5506 depicting the overall depletion as a metric ton of per capita by the Vise grad communities. The utilization of energy had a mean of 3.0615 indicating a 306.15% energy used as a measure of oil, gas, coal, and nuclear within the Vise grad communities. It is corroborated to economic progress having a mean of 0.5349 value of per capita of income. The governments ENTX receives accounted for an average mean of 0.8490 (84.90%)

4.5. Regression Synopsis

To analyze the regression and test the affiliation between the variables in equations 1,2, and 3 the FMOLS and DOLS technique was employed. The synopsis of the results for equation 1 is demonstrated in Table 7. ENC and ECP had a favorable material nexus with environmental deterioration in the Vise grad communities. With a coefficient of 0.0182 (1.82%) indicating that these regions' contributions accounted for 1.82% with a corresponding improvement in their economic progress by 0.0268 (2.68%). The indicator EXTX was tested in equation 2 and demonstrated in Table 8. The results indicated that ENTX had an unfavorable correlation with EVD. This implies that a coefficient value of −0.2013 (20.13%) when imposed will cause to present the use of oil, coal, gas, and nuclear energy in the Vise grad regions. The moderating role of environmental taxes was tested in equation 3 on the link between ENC-EVD. The results are depleted in Table 8, the findings show that EXTX*ENC had an inverse affiliation with EVD. With the value of −0.4041 (40.41%). Other factors of environmental deterioration were added to the model as controls variables (HUC, TRO, and URB). The findings indicated that these variables had an unfavorable material effect on reduction on the dependence of nonrenewable consumption in the V4 group of nations (−0.0158-HUC, −0.5780-URB, and −0.2502-TRO). These coefficients values indicate that HUC, URB, and TRO have a depreciation effect on EVD and an appreciation on quality of the environment in the Vise grad communities.

5. DISCUSSIONS

This research seeks the dynamic effect of ENC on the deterioration of the environment. Again, the ENTX as a moderating role was explored on the link between ENC-EVD for Vise grad region. The analysis of the regression model developed, the FMOLS and DOLS was employed for the panel investigation for the period 1994-2021. From Tables 6-8 the results of the association are presented. As presented in Table 7, ENC and ECP combinedly had a favorable affiliation with EVD. With economic progress rising, more energy has been consumed by manufacturing enterprises. Consumption on non-renewable energy in the early stages of production means deterioration of the environment. This is confirmation of the EKC model that energy consumption and economic progress are linked with each other. Numerous recent empirical investigations have claimed a similar positive link between ENC, ECP, and EVD. The affiliation between energy use, environmental pollution, and economic progress was investigated in South Asian societies. The article's synopsis was that rising energy consumption and economic development were causing the ecological condition to deteriorate (Mughal et al., 2022). According to Munir and Riaz (2020), the NARDL model was used to examine the effects of oil, gas, and coal usage between 1975 and 2018 in most industrialized economies, including the USA, Australia, and China. Their findings indicate that when energy use rises, so do these regions' carbon emissions.

However, in Table 8 environmental taxes had a significant negative nexus with EVD in the Vise grad nations. The implication of these results indicates that when taxes are introduced on non-renewable energies EVD depreciates and quality of life appreciates in the Vise grad regions. Recently research by Esen et al. (2021) investigation on the impact of ENTX in the EU communities employed the PSTR model to choose 15 States between 1995 and 2016 and found that the effective environmental taxes in these areas greatly reduced environmental pollution. Additionally, using the MMQR and Dumitrescu and Hurlin models, Xie and Jamaani, (2022) analyzes

Table 5: Descriptive output

	EVD	ENC	ECP	ENTX	HUC	URB	TRO
Mean	4.9571	3.0615	0.5349	0.8490	1.9895	1.8035	1.7540
Median	4.7648	3.4093	0.6172	0.8633	1.9873	1.7903	1.7644
Maximum	5.5506	3.6523	1.0334	0.9518	2.0359	1.8737	1.9835
Minimum	4.4834	1.9414	−0.5943	0.6720	1.9633	1.7301	1.3437
SD	0.3732	0.6689	0.2732	0.0538	0.0150	0.0481	0.1694
Skewness	0.3941	−0.8259	−1.4527	−1.1163	0.8335	0.0140	−0.6295
Kurtosis	1.6085	1.7563	5.9385	3.9215	3.6502	1.6810	2.5716
Jarque-Bera	10.549	17.6365	70.444	24.066	13.209	7.1796	7.2957
Probability	0.0051	0.0001	0.0000	0.0000	0.0013	0.0276	0.0260
Sum	490.7621	303.0889	52.9625	84.0525	196.96	178.5488	173.6548
Sum Sq. Dev.	13.65470	43.86028	7.316742	0.284084	0.022221	0.227191	2.812528
Observations	99	99	99	99	99	99	99

Table 6: Testing model 1

The impact of ENC on EVD (ENC-EVD)						
	FMOLS			DOLS		
	Coefficients	t-value	P-value	Coefficients	t-value	P-value
ENC	0.0182	1.3369	0.1855	1.9631	3.6691	0.1694
ECP	0.0268	2.6919	0.0089	-0.0523	-3.8883	0.1603
HUC	−0.2716	−1.2075	0.2312	1.0106	1.7756	0.3265
URB	−2.7158	−2.3670	0.0207	14.011	1.5489	0.3650
TRO	−0.1803	−2.3082	0.0239	0.0914	0.6127	0.6500
R-squared			0.9979			0.9977
Adjusted R-squared			0.9976			0.9496
S.E. of regression			0.0185			0.0050
Long-run variance			0.0004			0.0007

Significance level ***, **, * 1%, 5%, 10% respectively

Table 7: Testing model 2

The impact of ENT on EVD (ENT-EVD)						
	FMOLS			DOLS		
	Coefficients	t-value	P-value	Coefficients	t-value	P-value
ENTX	−0.2013	2.4932	0.0149	−0.0471	−5.2578	0.0343
ECP	0.0401	2.8328	0.0059	1.6459	6.2840	0.0244
HUC	−0.1133	−0.3651	0.7160	0.6855	2.3398	0.1442
URB	−0.9458	−2.3059	0.0239	7.8363	2.4555	0.1334
TRO	−0.2971	−8.0850	0.0000	0.1185	1.0616	0.3996
R-squared			0.9960			0.9999
Adj. R-squared			0.9956			0.9999
S.E. of regression			0.0250			0.0037
Long-run variance			0.0010			0.007

Significance level ***, **, * 1%, 5%, 10% respectively.

Table 8: Testing model 3

Moderating ENTX on EVD-ENC						
	FMOLS			DOLS		
	Coefficients	t-value	P-value	Coefficients	t-value	P-value
ENC	0.3748	2.5473	0.0130	0.536538	3.074882	0.0028
ECP	0.0421	3.2956	0.0015	0.028801	1.833227	0.0701
ENTX	−0.5164	2.7107	0.0084	−0.789554	2.951653	0.0041
HUC	−0.0150	−0.0536	0.9573	−0.319444	−0.940118	0.3497
URB	−0.5780	−1.4330	0.1561	−0.433514	−0.931927	0.3539
TRO	−0.2502	−6.8367	0.0000	−0.225947	−5.589591	0.0000
ENC*ENTX	−0.4041	−2.3849	0.0197	−0.560501	−2.762584	0.0070
R-squared			0.9963			0.9930
Adjusted R-squared			0.9958			0.9922
S.E. of regression			0.0244			0.0327
Long-run variance			0.0007			0.0014

Significance level ***, **, * 1%, 5%, 10% respectively.

ENTX and CO_2 of a set of G7 countries between 1990 and 2020. The analytical findings support how important environmental fees are in reducing carbon emissions.

Further, Table 9 produced the interaction results ENC*ENTX with a negative coefficient. This indicates that environmental taxes can be used to reduce the dependance on coal, oil, and gas as a form of energy consumption in the Vise grad nations. Though there are no literary work that has confirm the interaction effect of ENC * ENTX-EVD, research in the G7 by (Doğan et al., 2022) indicated that strict environmental tax laws with the regions will shift enterprises consumption on non-renewable energies to clean production energies. Similar, investigation in E7 nations shows that environmental taxes had a negative association with environmental pollution (Yunzhao, 2022). Lin and Jia, (2019) examined the tax system in China for enterprises that use energy. Their CGE investigation illustrated that altering the tax policy's structure and the payment rate has a favorable effect on the quantity of energy used.

HUC exhibits a negative affiliation with environmental deterioration. The development in human capital and awareness of depletion of the environment in the Vise grad regions. In Sub-Saharan nations, literary work on HUC and environmental quality were undertaken (Zhang et al., 2022). Adopting four measures of HUC (cost and enrolment in basic and secondary school), the results demonstrate an improvement in environmental quality between 1996 and 2018. Similarly, Sharma et al., (2021) examined the relationship between GHS emission and farm activity emission by examining and analyzing data from BIMSTEC nations from 1985 to 2019. The research focused on HUC and renewable energy sources. The article's evaluation indicated that HUC has an immaterial relationship with GHS emission. On the part of the UBR-EVD the findings exhibited an inverse affiliation. Increase in urban movement means increased in urban emission. Musah et al. (2020) claims that URB increases the demand of high facilities including heating systems, electrical appliances, air conditioning, and kitchen appliances, raising concerns about the nations' environmental pollution rates. The negative coefficient indicates that governments and environmentalists in the Vise grad group of nations have proper urban planning in their various nations. The findings are not in support with Sun et al. (2022) conducted study on the impact of urbanization and renewable energy on carbon emissions in the MENA areas between 1991 and 2019. According to the analysis's demonstration, carbon emissions in MENA areas are brought on by rising urbanization and economic development., Grodzicki and Jankiewicz (2022) investigate how urbanization and renewable energy use affect C02 emissions in Europe. Using the spatiotemporal model and the 1995-2018 data period, the results indicate that urbanization and carbon emissions are leading to a fall in Eastern Europe and an increase in North Europe. Musah et al. (2022) analyzed G-20 communities from 1992 to 2018 by examining the pollution model. According to the paper, the G-20 States' urbanization was a major contributor to carbon emissions.

Lastly, trade openness presented a negative association with environmental deterioration. It is believed that more trade opens the economy, creating jobs, and lowers poverty. These institutions use more energy as a nation's industrialization grows. The conclusions of this study were not corroborated by studies conducted in China; nonetheless, the relationship between TRO and EVD was investigated (Jun et al., 2020). Trade openness is favorably affiliated with environmental pollution in a direct and materially significant way, according to the wavelet-coherence evaluation. Utilizing the EKC model, (Van Chien, 2020) conducted tests with variables pertaining to TRO and environmental pollution. Employing data from 1990 to 2014 using an ARDL analysis, we find that TRO has appreciated in affiliation to carbon emissions by 29.4%.

6. CONCLUSION AND RECOMMENDATION FOR POLICY

The topic of environmental protection has drawn the attention of policymakers and the scholarly community in the modern industrialized era. Literary works have shown that many factors affect the appreciation of deterioration of the environment. From 1994 to 2021, this study set out to investigate what factors contributed to environmental degradation in the Vise grad region. The regression methods employed were FMOLS and DOLS to check the link between the dependent variable environmental deterioration and independent variable energy consumption. The investigation moderated environmental taxes and added control variables economic progress, human capital, urbanization, and trade openness. The article made use of the EKC fish-hood shape hypothesis for the affiliation of the indicators. The predicted coefficients reveal the effect of each explanatory variable on EVD in the long term. As presented in the analysis, ENC had a positive nexus with EVD. Similarly, ECP had a material association with EVD. Again, ENTX exhibited an inverse association with EVD. The research moderated for the link between ENC and ENTX with EVD. The empirical results exhibited a negative moderating link with EVD. Lastly, HUC, URB, and TRO produced a positive nexus with EVD.

The governments of these nations can offer tax breaks to businesses who employ renewable energy sources. In addition, the Vise grad countries will succeed in reducing EVD through the implementation of policies including systems for energy efficiency, investments in low-carbon metropolitan centers, and the enlargement of electricity markets across the nations. To achieve the reverse reaction of ENC*ENTX on EVD, the study suggests that policymakers zero down on domestic consumption, especially in the economic development sectors that rely on traditional energy sources to produce goods and services. Environmental laws, restrictions, and reforms should, therefore, apply to industrial operations that generate a disproportionate amount of carbon emissions. This study also demonstrates that the Vise grad's development strategies use eco-friendly resources to generate outputs as it advances its economic progress. Thirdly, we suggested that the Vise grad nations' politicians should present practical strategies for sustaining the population's enrollment rate and education on the impacts of environmental deterioration in order to recognize the influence of HUC on EVD. Similar to this, businesses, entrepreneurs, and organizations should be urged to support green trade and investment as well as green business.

Fourth, decision-makers in the Vise grad economies may rely on energy innovation as a crucial instrument for addressing carbon dioxide emissions given its impact on environmental pollution remediation. Innovations in pertinent environmental technology can give enterprises a competitive edge in addition to the advantages of a cleaner environment because of investments in modern technologies and renewable energy. Lastly, we recommend that stakeholders and urban planners in Vise grad nations address the unfavorable effects of urbanization on EVD by implementing suitable land acquisition. Decoupling urbanization from EVD is essential for enhancing energy efficacy in the home and industrial sectors, particularly in Vise grad nations.

The study's weaknesses stem from the fact that, although each economy may respond to EVD differently, it examines all Vise Grad regions simultaneously. Other crucial factors that might significantly affect environmental deterioration, such as good governance and its indications green energy, political stability, and research and development, were not included in our study model. By including these factors and employing additional environmental theories, the researchers will expand the scope of this evaluation in the future. Additionally, collaboration variables like globalization could be added to explore how these variables affect environmental contamination in various jurisdictions.

7. ACKNOWLEDGMENT

The authors do acknowledge the enormous contribution rendered by Professors from Tomas Bata University and Technical University of Kosice.

8. FUNDING

This research was supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences as part of the research project VEGA No. 1/0590/22.

REFERENCES

Anwar, N., Elfaki, K.E. (2021), Examining the relationship between energy consumption, economic growth, and environmental degradation in Indonesia: Do capital and trade openness matter? International Journal of Renewable Energy Development, 10(4), 769-778.

Bajja, S., Radoine, H., Celik, A., Dakyaga, F., Damrah, S. (2024), Human capital and manufacturing activities under environmentally-driven urbanization in the MENA region. Frontiers in Environmental Science, 11, 1322789.

Boukar, M., Sapnken, F.E., Diboma, B., Ewodo-Amougou, M.R., Sama, J.M.S., Tamba, J.G. (2024), Exploring the relationship between CO_2 emissions and fuel consumption in road transport: Empirical evidence from Chad. International Journal of Energy Economics and Policy, 14(2), 206-217.

Breusch, T.S., Pagan, A.R. (1980), The Lagrange multiplier test and its applications to model specification in econometrics. The Review of Economic Studies, 47(1), 239-253.

Chaabouni, S., Saidi, K. (2017), The dynamic links between carbon dioxide (CO_2) emissions, health spending and GDP growth: A case study for 51 countries. Environmental Research, 158, 137-144.

Chen, Y., Zhao, C., Chen, S., Chen, W., Wan, K., Wei, J. (2023), Riding the green rails: Exploring the nexus between high-speed trains, green innovation, and carbon emissions. Energy, 282, 128955.

Chudik, A., Pesaran, M.H. (2015), Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. Journal of Econometrics, 188(2), 393-420.

Chukwudi Udeagha, M., Ngepah, N. (2022), Does trade openness mitigate the environmental degradation in South Africa? Environmental Science and Pollution Research, 29, 19352-19377.

De Pascale, G., Fiore, M., Contò, F. (2021), Short and long run environmental tax buoyancy in EU-28: A panel study. International Economics, 168, 1-9.

Doğan, B., Chu, L.K., Ghosh, S., Diep Truong, H.H., Balsalobre-Lorente, D. (2022a), How environmental taxes and carbon emissions are related in the G7 economies? Renewable Energy, 187, 645-656.

Esen, Ö., Yıldırım, D.Ç., Yıldırım, S. (2021), Pollute less or tax more? Asymmetries in the EU environmental taxes-ecological balance nexus. Environmental Impact Assessment Review, 91, 10662.

Grodzicki, T., Jankiewicz, M. (2022), The impact of renewable energy and urbanization on CO_2 emissions in Europe - Spatio-temporal approach. Environmental Development, 44, 100755.

Huseynli, N. (2024), Investigation of the effect of energy consumption on carbon emissions in Azerbaijan in the context of the environmental Kuznets Curve. International Journal of Energy Economics and Policy, 14(2), 53-58.

Hussain, M.N., Li, Z., Sattar, A. (2022), Effects of urbanization and nonrenewable energy on carbon emission in Africa. Environmental Science and Pollution Research, 29(17), 25078-25092.

Jun, W., Mahmood, H., Zakaria, M. (2020), Impact of trade openness on environment in China. Journal of Business Economics and Management, 21, 1185-1202.

Khan, H., Weili, L., Khan, I. (2022), Environmental innovation, trade openness and quality institutions: An integrated investigation about environmental sustainability. Environment, Development and Sustainability, 24(3), 3832-3862.

Kusiyah, K., Mushtaq, M., Ahmed, S., Abbas, A., Fahlevi, M. (2024), Impact of urbanization on environmental eminence: Moderating role of renewable energy. International Journal of Energy Economics and Policy, 14(2), 244-257.

Kwamena Tachie, A., Xingle, L., Dauda, L., Mensah, C.N., Appiah-Twum, F., Mensah, I.A. (2020), The influence of trade openness on environmental pollution in EU-18 countries. Environmental Science and Pollution Research, 27, 35535-35555.

Latief, R., Sattar, U., Javeed, S.A., Gull, A.A., Pei, Y. (2022), The environmental effects of urbanization, education, and green innovation in the union for Mediterranean Countries: Evidence from quantile regression model. Energies, 15(15), 5456.

Li, K., Hu, E., Xu, C., Musah, M., Kong, Y., Mensah, I.A., Zu, J., Jiang, W., Su, Y. (2021), A heterogeneous analysis of the nexus between energy consumption, economic growth and carbon emissions: Evidence from the Group of Twenty (G20) countries. Energy Exploration and Exploitation, 39(3), 815-837.

Lin, B., Jia, Z. (2019), How does tax system on energy industries affect energy demand, CO_2 emissions, and economy in China? Energy Economics, 84, 104496.

Liu, H., Zafar, M.W., Sinha, A., Khan, I. (2023), The path to sustainable environment: Do environmental taxes and governance matter? Sustainable Development, 31(4), 2278-2290.

Liu, X., Dong, X., Li, S., Ding, Y., Zhang, M. (2021), Air pollution and high human capital population migration: An empirical study based on 35 major cities in China. Sustainable Production and

Consumption, 27, 643-652.
Mahmood, N., Wang, Z., Hassan, S.T. (2019), Renewable energy, economic growth, human capital, and CO_2 emission: An empirical analysis. Environmental Science and Pollution Research, 26(20), 20619-20630.
Mohanty, S., Sethi, N. (2022), The energy consumption-environmental quality nexus in BRICS countries: The role of outward foreign direct investment. Environmental Science and Pollution Research, 29(13), 19714-19730.
Mughal, N., Arif, A., Jain, V., Chupradit, S., Shabbir, M.S., Ramos-Meza, C.S., Zhanbayev, R. (2022), The role of technological innovation in environmental pollution, energy consumption and sustainable economic growth: Evidence from South Asian economies. Energy Strategy Reviews, 39, 100745.
Musah, M., Adjei Mensah, I., Alfred, M., Mahmood, H., Murshed, M., Yaw Omari-Sasu, A., Boateng, F., Dery Nyeadi, J., Paa Kwesi, C. (2022), Reinvestigating the pollution haven hypothesis controlling for cross-sectional dependency and slope heterogeneity issues: Evidence from G-20 countries. Environmental Science and Pollution Research, 29, 31330-31347.
Musah, M., Kong, Y., Mensah, I.A., Antwi, S.K., Donkor, M. (2021), The connection between urbanization and carbon emissions: A panel evidence from West Africa. Environment, Development and Sustainability, 23, 11525-11552.
Omoke, P.C., Nwachukwu, T., Ibrahim, A., Nwachukwu, O. (2022), Asymmetric impact of financial development, trade openness, and environmental degradation on economic growth in Venezuela. Environmental Science and Pollution Research, 29(18), 27411-27420.
Pata, U.K. (2021), Renewable and non-renewable energy consumption, economic complexity, CO_2 emissions, and ecological footprint in the USA: Testing the EKC hypothesis with a structural break. Environmental Science and Pollution Research, 28, 846-861.
Rehman, A., Radulescu, M., Cismas, L.M., Alvarado, R., Secara, C.G., Tolea, C. (2022), Urbanization, economic development, and environmental degradation: Investigating the role of renewable energy use. Sustainability, 14(15), 9337.
Saqib, N., Abbas, S., Ozturk, I., Murshed, M., Tarczyńska-Łuniewska, M., Mahtab Alam, M., Tarczyński, W. (2024), Leveraging environmental ICT for carbon neutrality: Analyzing the impact of financial development, renewable energy and human capital in top polluting economies. Gondwana Research, 126, 305-320.
Shan, H., Wong, W.K., Hu, H., Al Shraah, A., Alromaihi, A., The Cong, P., Thi Minh Uyen, P. (2024), Fintech innovation for sustainable environment: Understanding the role of natural resources and human capital in BRICS using MMQR. Resources Policy, 88, 104468.
Sharma, G.D., Shah, M.I., Shahzad, U., Jain, M., Chopra, R. (2021), Exploring the nexus between agriculture and greenhouse gas emissions in BIMSTEC region: The role of renewable energy and human capital as moderators. Journal of Environmental Management, 297, 113316.
Suleman, S., Boukhris, M., Kayani, U.N., Thaker, H.M.T., Cheong, C.W.H., Hadili, A., Tehseen, S. (2024), Are trade openness drivers relevant to carbon dioxide emission? A study of emerging economies. International Journal of Energy Economics and Policy, 14(2), 183-196.
Sun, Y., Li, H., Andlib, Z., Genie, M.G. (2022), How do renewable energy and urbanization cause carbon emissions? Evidence from advanced panel estimation techniques. Renewable Energy, 185, 996-1005.
Tan, Z., Wu, Y., Gu, Y., Liu, T., Wang, W., Liu, X. (2022), An overview on implementation of environmental tax and related economic instruments in typical countries. Journal of Cleaner Production, 330, 129688.
Udeagha, M.C., Ngepah, N. (2022), Does trade openness mitigate the environmental degradation in South Africa? Environmental Science and Pollution Research, 29(13), 19352-19377.
Umar, M., Mirza, N., Hasnaoui, J.A., Rochoń, M.P. (2022), The nexus of carbon emissions, oil price volatility, and human capital efficiency. Resources Policy, 78, 102876.
Van Chien, N. (2020), Energy Consumption, income, trading openness, and environmental pollution: Testing environmental Kuznets Curve Hypothesis. Journal of Southwest Jiaotong University, 55.
Wang, Y., Yu, L. (2021), Can the current environmental tax rate promote green technology innovation? - Evidence from China's resource-based industries. Journal of Cleaner Production, 278, 123443.
Wenlong, Z., Tien, N.H., Sibghatullah, A., Asih, D., Soelton, M., Ramli, Y. (2023), Impact of energy efficiency, technology innovation, institutional quality, and trade openness on greenhouse gas emissions in ten Asian economies. Environmental Science and Pollution Research, 30(15), 43024-43039.
Xiao, J., Shen, L., Du, X. (2023), Exploring the effect of human capital on carbon emissions: Evidence from 125 countries. Environmental Science and Pollution Research, 30(36), 85429-85445.
Xie, P., Jamaani, F. (2022), Does green innovation, energy productivity and environmental taxes limit carbon emissions in developed economies: Implications for sustainable development. Structural Change and Economic Dynamics, 63, 66-78.
Yasin, I., Ahmad, N., Chaudhary, M.A. (2021), The impact of financial development, political institutions, and urbanization on environmental degradation: Evidence from 59 less-developed economies. Environment, Development and Sustainability, 23(5), 6698-6721.
Yu, S., Wang, X., Liu, J., Wei, F. (2023), Role of mining waste trade on green development in China: Policy implications for circular economy. Resources Policy, 86, 104147.
Yunzhao, L. (2022), Modelling the role of eco innovation, renewable energy, and environmental taxes in carbon emissions reduction in E-7 economies: Evidence from advance panel estimations. Renewable Energy, 190, 309-318.
Zhang, M., Ajide, K.B., Ridwan, L.I. (2022), Heterogeneous dynamic impacts of nonrenewable energy, resource rents, technology, human capital, and population on environmental quality in Sub-Saharan African countries. Environment, Development and Sustainability, 24(10), 11817-11851.
Zhang, S., Chen, K. (2023), Green finance and ecological footprints: Natural resources perspective of China's growing economy. Resources Policy, 85, 103898.