Journal of Environmental Science and Economics
https://doi.org/10.56556/jescae.v3i4.1091
ISSN: 2832-6032

RESEARCH ARTICLE

Economic Indicators and Environmental Expenditure: A Re-evaluation of the Kuznets Curve in the EU-27

Shabbir Ahmad

Independent Researcher, Islamabad, Pakistan

Corresponding Author: Shabbir Ahmad. Email: schabbir1@gmail.com
Received: 26 November, 2024, Accepted: 20 December, 2024, Published: 21 December, 2024

Abstract

This study uses data from the European Union (EU-27) member states to examine the relationship between environmental expenditure and key socioeconomic indicators, including Gross Domestic Product (GDP) per capita, population size, urban population and unemployment rate. The analysis investigates if environmental expenditure follows the patterns suggested by the Environmental Kuznets Curve (EKC) hypothesis by applying linear and quadratic regression models. The results show a strong positive relationship between urbanization and environmental expenditure. However, rather than following the expected inverted U-shaped curve suggested by the EKC, the relationship between GDP per capita and environmental expenditure is more linear. The study finds a fairly significant negative relationship between unemployment and environmental expenditure but no significant relationship is observed between population size and environmental spending. These findings have significant policy implications as they highlight how urbanization affects environmental expenditure and the necessity of devising economic strategies that incorporate environmental protection at different stages of economic growth.

Keywords: Environmental Kuznets Curve; environmental expenditure; EU-27; GDP per capita; urbanization; unemployment rate

Introduction

Environmental expenditure is a crucial policy tool employed by governments to meet climate goals, mitigate environmental degradation and promote sustainable development. As countries around the world intensify their efforts to address issues associated with climate change, investments in environmental policies have become important for ensuring a sustainable future (Abbass et al., 2022). It is a pivotal factor for the EU-27 member states to meet their sustainability and carbon neutrality targets (Barrell et al., 2021) and a reflection of countries' commitment to environmental stewardship (Niu, 2024). There has been a surge in environmental spending in the recent past around the world. For instance, the EU environmental spending reached €130 billion in 2022 (Eurostat, 2024), indicating a steady increase in investment directed at achieving the region's sustainability targets. Previous research has examined the impact of environmental regulations on economic growth but the intricate relationship between environmental spending and socioeconomic factors remains an area of active research (Lenaerts, Tagliapietra, and Wolff, 2022). Socioeconomic factors like GDP per capita, unemployment rate, urbanization and population size may play a pivotal role in shaping countries' environmental policies because these variables determine the financial and social feasibility of sustainability measures implementation (Dalevska et al., 2019; Bhatti et al., 2024). Environmental expenditure is not only an indicator of a country's commitment to sustainability but also a crucial component of broader socioeconomic dynamics. However, such expenditure is dependent upon countries' economic condition. Countries with higher GDP per capita tend to spend more on environmental initiatives (Suhányi, Suhányiová, and Kočišová, 2023; Jayachandran, 2022). Moreover, countries with high GDP per capita generally have better environmental performance indices, suggesting that these countries tend to spend more on environmental infrastructure (Neagu, Ardelean and Lazăr, 2017). Furthermore, urbanization along with population growth have also been linked to environmental issues, necessitating governmental spending aimed at environmental initiatives (Jiang, Young and Hardee, 2008). Such relationships tend to be more common in developed regions, like the EU-27 (Suhányi, Suhányiová, and Kočišová, 2023; Romano et al., 2023).

The EU Green Deal (EGD) promotes the importance of resource allocation to sustainability initiatives, emphasizing the transformative effect of environmental spending in realizing ambitious targets aimed at climate change mitigation (Almeida et al., 2023). The EGD aims for a net-zero emissions by 2050 through investments in green technologies and infrastructure along with transitioning to a circular economy in the region (Kazak, 2020). Such initiatives could be funded through financial instruments like green taxation, which may not only promote sustainable practices but also foster economic growth (Phoomsavarth, 2023), leading to a rise in GDP per capita and job creation (Mulita, 2022). Environmental spending in light of the EGD may also result in sustainable urban development, leading to increased urbanization on account of cities adapting greener practices (Ruiz, Martin-Moreno, and Perez, 2023). The relationship between environmental expenditure and socioeconomic variables is complex and may not necessarily follow linear trends. Such non-linearities may emerge on account of different stages of economic development, demographic factors or policy priorities (Stern, 2004; Grossman and Krueger, 1995). The EKC suggests one of such non-linear relationships (Dinda, 2004; Halkos and Paizanos, 2013). It states that the initial stages of economic growth may result in a rise in environmental degradation but when economies reach higher income levels, the adverse impacts on the environment decline (Dinda, 2004). Developed countries, in particular, have shown similar trends at their various stages of development (Mohammed et al., 2024). The decline in environmental degradation is mainly due to technological advancements, countering the pollution effects of urbanization and income inequality (Ercan et al., 2024). Keeping in view the multifaceted nature of the relationship between environmental expenditure and key socioeconomic variables, this study uses both linear and quadratic models to provide nuanced analysis to better comprehend these dynamics and offer valuable insights for researchers and policymakers interested in interplay of economic growth and environmental sustainability. Quadratic models are particularly effective in capturing non-linearities like turning points in the relationship between environmental expenditure and GDP growth or urbanization rate. By focusing on the EU-27 member states, this study aims to analyse the relationships between environmental expenditure and socio-economic variables like GDP per capita, population size, Urbanization and unemployment rate. This analysis is important, because it highlights how a country's environmental policy and expenditure priorities are influenced by its economic and demographic conditions.

The rest of the paper is organized as follows. This section is followed by a comprehensive literature review, encompassing a detailed overview of the existing relevant literature. It is followed by data and methodology section. The subsequent section provides the analysis and results of the data, along with discussion of the results. The final part of this paper provides a concise conclusion of the study, including policy and future research recommendations.

Literature Review

The relationship between environmental expenditure and socioeconomic and demographic factors has been studied in literature in different contexts. For instance, GDP per capita is generally considered as a major driver of environmental expenditure (Upreti, 2015). However, this relationship is seldom uniform, as studies have highlighted the non-linear patterns (Cole and Elliott, 2003). Similarly, other variables like population size, urbanization and unemployment rates encompass layers of complexity, suggesting the multifaceted drivers of environmental spending and shaping policies.
This part of the paper provides an overview of the existing literature on the variables included in this study, focusing on theoretical and empirical underpinnings. It sets the foundation for the subsequent analysis, providing rationale for the models employed in this study.

GDP per capita

GDP per capita is often used to assess a country's economic development and financial condition (Upreti, 2015). A country's ability to invest in environmental protection is determined by the level of its economic development (Dasgupta et al., 2002). The EKC hypothesis has been extensively used in empirical studies concerning the relationship between environmental expenditure and GDP per capita. Countries with higher GDP per capita tend to allocate more resources to environmental protection. Same is the case in the EU (Eurostat, 2021). However, countries may experience diminishing returns on their environmental spending after reaching a certain threshold. Therefore, the relationship between GDP per capita and environmental expenditure may not follow a strict linear pattern (Grossman and Krueger, 1995; Dinda, 2004; Cole and Elliott, 2003; Halkos and Paizanos, 2013).

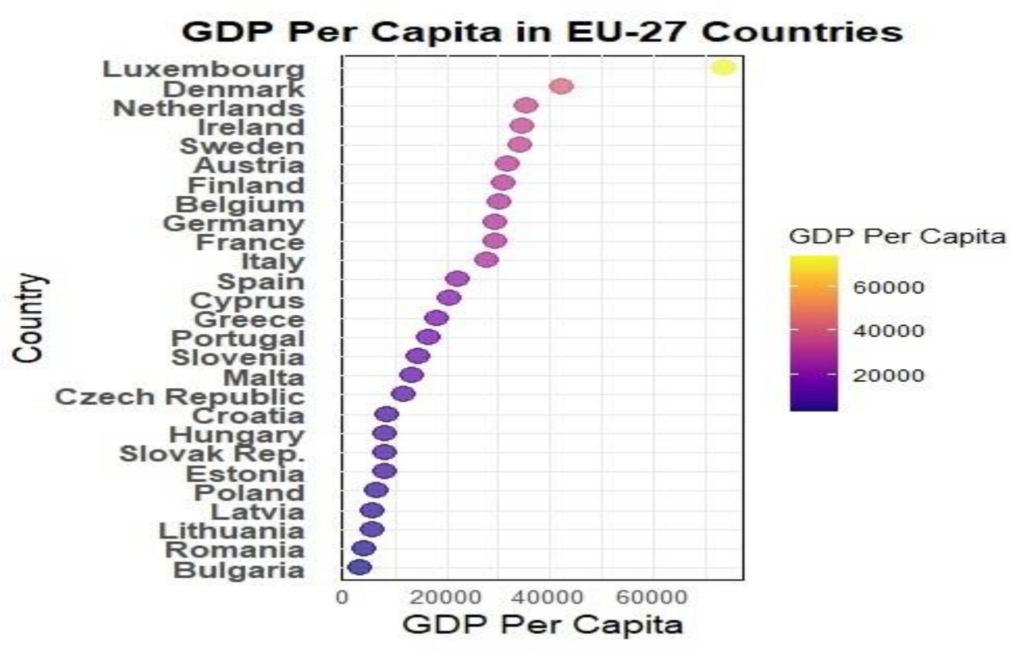

Figure 1. GDP per Capita in EU27

GDP per capita varies significantly among the EU member states, as depicted in Figure.1. It is mainly due to income inequalities (Ciurea and Cornelia, 2010), variations in labor utilization rates and different productivity levels (Mourre, 2009). That is why in Europe, the evidence supporting the EKC is mixed. Grossman and Krueger (1995) and Popsecu et al. (2023) provide evidence in favour of the EKC by observing inverted U-shaped curves between economic growth and environmental degradation. They argue that ecological footprints rise with income levels. However, when environmental awareness and new regulations become more prominent, it may eventually decline. Furthermore, Dritsaki et al. (2024) and Badulesco et al. (2019) find a positive relationship between environmental expenditure and GDP per capita. Some studies reveal that the relationship between environmental expenditure and GDP per capita is influenced by specific environmental variables. Leiter, Parolini and Winner (2011) argue that the outcomes of environmental investments can vary significantly across Europe based on institutional capacity, governance and the nature of environmental challenges. Similarly, Stern (2004) states that the effectiveness of environmental expenditure depends on how well environmental policies are integrated into the broader economic strategies. For instance, in Sweden and Denmark, the environmental regulations are in alignment with industrial strategies due to which environmental expenditure has resulted in positive economic and ecological outcomes. However, in Romania and Bulgaria, a more tenuous relationship between economic growth and environmental expenditure exists because governments prioritize economic growth over environmental protection (European Commission, 2018). Keeping in view the mixed empirical evidence and the potential non-linear relationship between GDP per capita and environmental expenditure, this study examines both linear and quadratic models to better understand the potential intricacies of this relationship.

Population Size

GDP per capita alone may not be sufficient to explain environmental expenditure as several other socioeconomic and demographic factors may also have an impact on a country's fiscal commitment to environmental protection. One of such variables is population size. The impact of population size on environmental expenditure is largely an unexplored area. Larger populations tend to put pressure on a countries' natural resources, necessitating robust environmental protection measures (Le Gallo and Ndiaye, 2021; Mohammed et al., 2024). This is relevant in the case of densely populated EU countries, such as Germany, France, and Italy (Eurostat, 2024). Figure. 2 shows that there has been a steady rise in population from 2001 to 2021 in the EU-27 member states. Larger populations may necessitate higher environmental expenditure to mitigate adverse environmental impacts. Similarly, Weber and Sciubba (2019) argue that regional population expansion in Western Europe has resulted in high levels of carbon emissions and Urbanization, validating the adverse impact of a larger population on the environment. Population structures vary greatly among the EU countries, resulting in different patterns in resource utilization, energy consumption and the level of Urbanization. Such a diversity in population structures may lead to varying levels of environmental degradation along with different environmental expenditure patterns (Mohammed et al., 2024). However, population size alone may not explain the environmental expenditure patterns. Environmental goals are more cost effective in more populous countries due to economies of scale. Fankhauser and Stern (2018) state that while larger population size may result in an increase in the absolute amount of environmental expenditure, the per capita expenditure may vary based on the countries' institutional frameworks, demographic factors and environmental priorities. While it is intuitive to presume that a large size population would result in environmental degradation leading to higher environmental expenditure. However, the relationship between the two variables is far more complex in the contemporary world. Moreover, the relationship between environmental expenditure and population size may not necessarily be linear. Countries with smaller populations like

Luxembourg may spend more on environmental protection on account of lifestyle choices and dietary patterns (Galli et al., 2023). This study explores whether larger EU countries allocate higher levels of environmental expenditure in comparison to the smaller states and whether this relationship remains consistent across different functional forms.

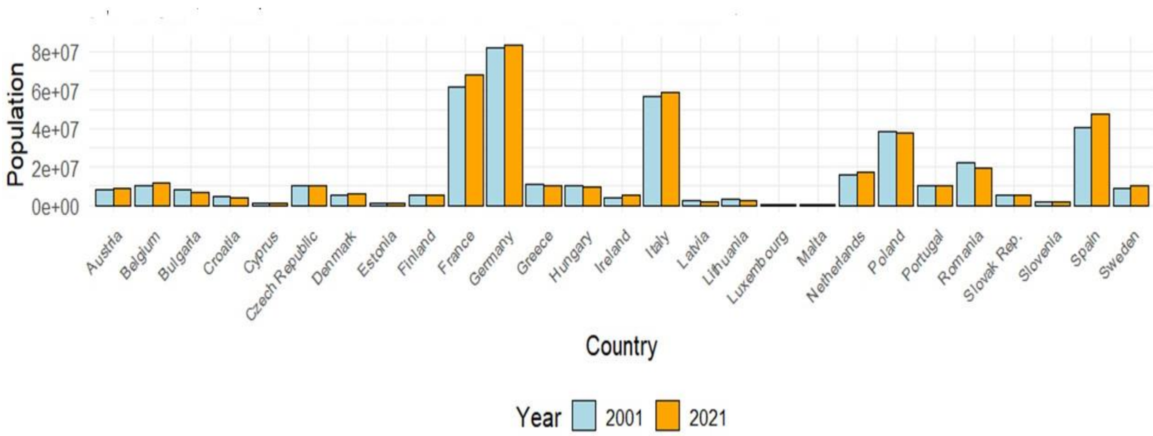

Figure 2. EU-27 Population Size 2001 vs. 2021

Urbanization Rate

Besides population size, urban population level may also impact the level of environmental expenditure (Singh, Shukla and Jain, 2024). Urbanization is a significant driver of environmental expenditure due to concentration of economic activities, population and infrastructure in cities (Hachaichi and Baouni 2020). Environmental challenges like air and water pollution, energy consumption and waste management are more prominent in urban areas, which necessitates higher environmental expenditure (Liang, Wang and Li, 2019; Di Clemente et al., 2021).

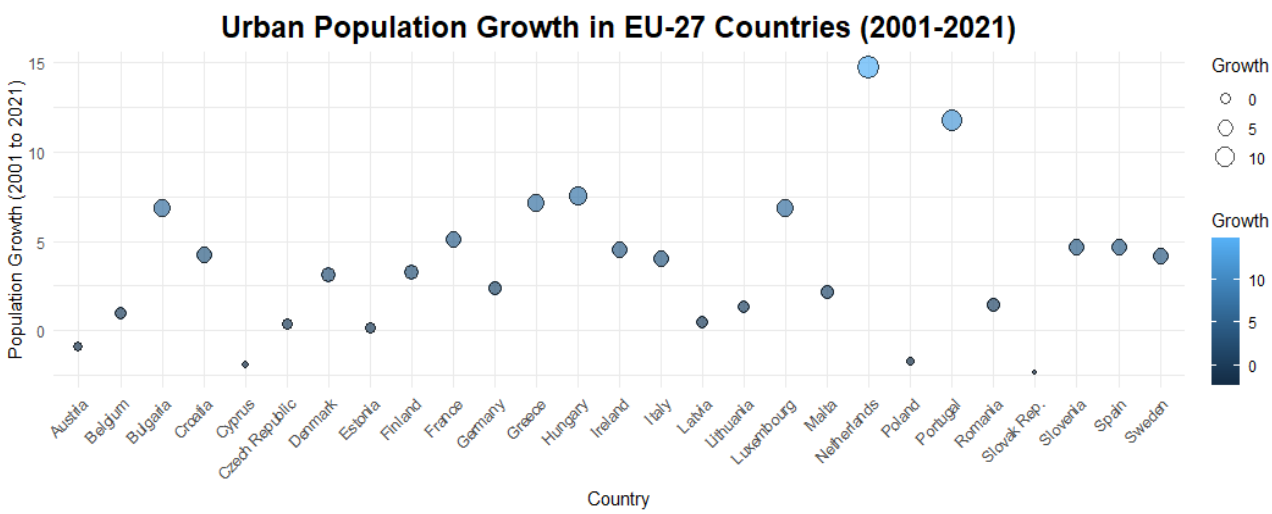

Figure 3. EU-27 Urbanization Rates

Urbanization has been a major contributor to environmental degradation and a driver of economic growth in the EU-27. The Netherlands has the highest urbanization rate as shown in Figure. 3 and may exhibit different environmental expenditure patterns in comparison to other EU member states (European Commission, 2020). Moreover, resource depletion and air pollution are more prevalent in Belgium and the Netherlands, two EU member states with high urban population densities. In response, governments have devised robust environmental policies, including increased investments in waste management, public transit and renewable energy (EEA, 2019).

Bowen and Hepburn (2014) suggest a direct correlation between Urbanization and environmental expenditure, drawing attention to the growing need for investment in environmental protection initiatives in the wake of urban expansion. Increased Urbanization correlates with higher energy consumption coupled with a rise in carbon emissions in most of the European countries, prompting governments to invest in environmental protection (Verbič, Satrovic and Muslija, 2021). Similarly, the European Environment Agency (EEA) notes that the EU-27 member states with high Urbanization rates tend to have higher levels of environmental expenditure (EEA, 2019). However, the complex relationship between Urbanization and environmental expenditure is influenced by several socioeconomic factors and may not be linear (Wang, Wang and Li, 2022; Liddle, 2017). For instance, Zhao et al. (2017) contend that variations in income levels and regional characteristics may cause shifts in the relationship between Urbanization and environmental expenditure. One of the objectives of this study is to explore whether there is a linear relationship or a diminishing return at higher levels of Urbanization between increased environmental expenditure and higher Urbanization rates.

Unemployment Rate

Besides the urban landscape, labour market conditions like unemployment rate may also have an impact on the level of environmental expenditure, particularly in countries that are under financial strain (Yip, 2018). A high unemployment rate can be interpreted as an indicator of economic distress (Collins, 2009) and may impact governments' spending priorities, resulting in lower environmental spending. In contrast, lower unemployment rates may allow for increased environmental spending (Meyer, 2016).

It is evident from Figure.4 that unemployment rates in the EU-27 member states fluctuate greatly in some countries, while in others these remain relatively stable. Such fluctuations in unemployment rates may affect environmental spending in these countries (Meyer, 2016). Similar to Urbanization, several variables may influence the relationship between unemployment and environmental spending. When unemployment rates are high, governments may put economic recovery ahead of environmental protection to create jobs. It may lead to a decline in environmental expenditure (Holum and Jakobsen, 2024). Same has happened in the EU over the years. Meyer (2016) reports that rising unemployment rates in some of the EU countries result in a decline in environmental spending because individuals prioritize economic survival over environmental protection. In contrast, Rosiek (2013) contends that insufficient environmental expenditure during economic downturns in the EU member states may lead to high unemployment due to stagnation of green industrial sectors.

Contemporary literature has explored sector-specific environmental spending. For instance, Kammen (2008) and Pollin, Heintz and Garrett-Peltier (2014) conclude that investments in renewable energy industry and sustainable infrastructure have significant potential for job creation. It implies that environmental spending can help lower the unemployment rate. Similarly, the European Green Deal emphasizes the potential of environmental expenditure in fostering economic resilience (European Commission, 2019). Fankhauser et al. (2013) also argue that investments in green technologies and infrastructure may not only address environmental challenges but also create new job opportunities. The EU's Just Transition Fund, which aims to assist member states that rely significantly on pollution-intensive industries, is an example of how environmental policies are used to promote economic development and reduce unemployment (European Commission, 2021).

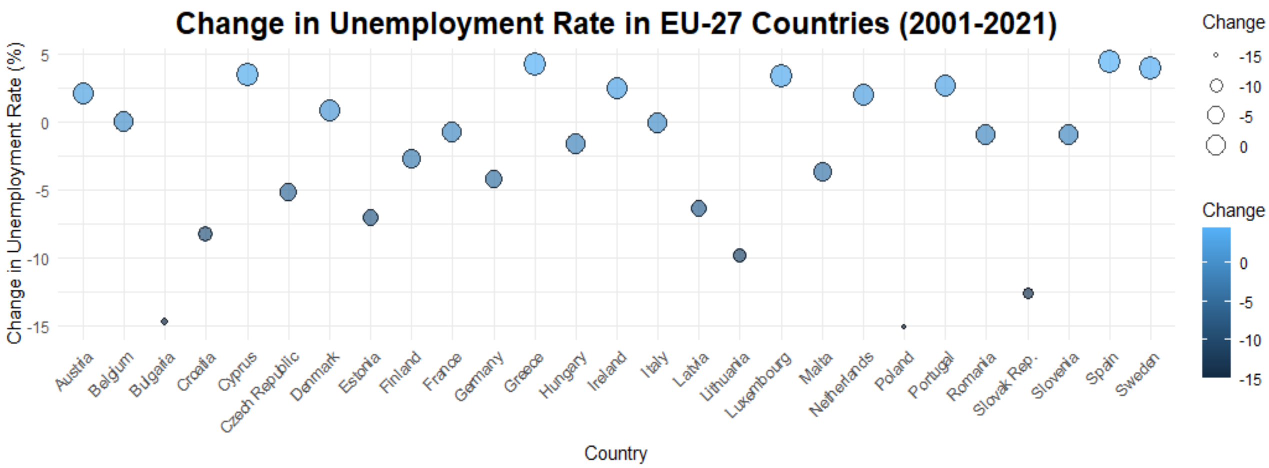

Figure 4. EU-27 Unemployment Rates

However, the relation between environmental spending and unemployment is more nuanced. While governments may hesitate to enhance environmental expenditure in the wake of high unemployment rate, initiatives resulting from environmental investment may serve as drivers of job creation, potentially contributing to economic recovery (Liu and Feng, 2022). As a result, depending on the regulatory frameworks and the nature of environmental initiatives implemented across the EU member states, the relationship between environmental expenditure and unemployment rate may differ (Fetting, 2020).
Although contemporary literature sheds light on these relationships, it reveals significant research gaps as the precise impacts of these variables on environmental expenditure are understudied. Therefore, the interplay of these variables in the context of the EU-27 necessitates a comprehensive examination. This study seeks to fill these gaps in literature by employing a variety of statistical tools to examine the relationship between environmental expenditure and key socio-economic variables.

Methodology

Data and Variables

The study uses panel data from the EU-27 countries from the period 2001 to 2021. Table. 1 provides details about the variables included in this study. Data for the dependent variable, Environmental Protection Expenditure (EPE), is sourced from the World Bank DataBank, providing records of environmental expenditure across the EU-27. The study involves four socioeconomic indicators serving as independent variables. Data for real GDP per capita (GDPPC) is extracted from the Eurostat. It is employed to examine its impact on environmental expenditure within the context of the EKC hypothesis. Data for Population Size (POP) is sourced from the Eurostat while the Urbanization (URB) data is collected from World Bank DataBank and serves to analyse the influence of urban growth on environmental expenditure. The Unemployment Rate (UNEM) data is also retrieved from the World Bank DataBank. The collected data ensures a comprehensive coverage of economic, environmental and demographic variables across the EU-27 region.

Table.1. Source and Description of Variables

Variables	Description	Unit of Measurement	Source
EPE	Environmental Protection Expenditure	Current US$	World Bank
GDPPC	Real GDP per Capita	Current US$	World Bank
POP	Population Size	Number of People	Eurostat
URB	Urbanization Rate	Percent of total population	World Bank
UNEM	Unemployment Rate	Percent of total labor force	World Bank

Empirical Methods

The study uses two regression models, i.e., linear and quadratic, to estimate the relationship between EPE and the four independent variables. Quadratic model is employed to determine whether the relationship of EPE and GDPPC reveals a U-shaped curve, as suggested by the EKC. The regression analysis is preceded by correlation analysis along with Granger Causality test.

Correlation Analysis

Correlation analysis is conducted initially to identify the strength and direction of the relationships between independent and dependent variables. The Pearson and Spearman coefficient matrices are calculated for each pair of variables to examine the extent of correlation and whether these are positively or negatively correlated.

Granger Causality Test

Correlation matrices are followed by Granger causality test to address the question of whether the one time series, i.e., GDPPC, POP, URB and UNEM can be used to predict another time series, i.e., EPE. Shahbaz et al. (2013) employed the Granger causality test to examine the causal relationship between economic growth, carbon emissions and energy consumption to determine the directionality between these variables over time. Fodha and Zaghdoud (2010) used it to analyse the causal relationship between economic growth and pollutant emissions in the context of the EKC hypothesis. In this study, it is crucial to use the Granger causality test as simple correlation may overlook directional causality.

Regression Analysis

Two regression models are employed to estimate the relationships between the above-mentioned variables.

Linear Model

A multiple linear regression model is used to examine the direct relationship between dependent variables like GDPPC, POP, URB, and UNEM and the dependent variable, i.e., EPE. Martınez-Zarzoso and Bengochea-Morancho (2004) used multiple linear regression to determine the relationship between economic growth and environmental degradation. Cagatay and Mihci (2006) also employed a linear regression model to determine the impact of environmental policies and economic growth on trade patterns.

The multiple linear regression model in this study can be written as follows.

$$EPE = \beta 0 + \beta 1.GDPPC + \beta 2.POP + \beta 3.URB + \beta 4.UNEM + \varepsilon$$

Where $\beta 0$ is the intercept, $\beta 1, \beta 2, \beta 3$ and $\beta 4$ are the coefficients for GDP per capita, Population, Urban Population and Unemployment, respectively. ε is the error term.

Quadratic Model

The non-linear relationships are determined through a quadratic regression model, in line with the EKC. Dinda (2004) and Stern (2004) employed quadratic regression models to examine the relationship between economic growth and environmental indicators in light of the EKC hypothesis. This study aims to capture the relationship between GDP per capita and environmental expenditure in the context of the EKC hypothesis.

The quadratic regression model in this study can be written as follows.

$$\begin{aligned} EPEvalue = {} & \beta 0 + \beta 1.GDPPCvalue + \beta 2.GDPPCsquared + \beta 3.URBvalue + \beta 4.URBsquared \\ & + \beta 5.POPvalue + \beta 6.POPsquared + \beta 7.UNEMvalue + \beta 8.UNEMsquared + \varepsilon \end{aligned}$$

Where EPEvalue is the environmental protection expenditure (dependent variable), GDPPCvalue is the gross domestic product per capita, GDPPCsquared is the squared term for GDP per capita to capture non-linear effects, URBvalue is the urbanization rate, URBsquared is the squared term for urbanization rate to model non-linear relationships, POPvalue is the population size, POPsquared is the squared term for population size, UNEMvalue is the unemployment rate, UNEMsquared is the squared term for unemployment rate, β0, β1,…, β8 are the coefficients to be estimated and ϵ is the error term. Data is analysed through R version 4.4.1.

Results and Discussion

This section encompasses results from the estimated methods discussed in the methodology part of this study. The preliminary analysis encompasses determining variable densities. Figure. 5 shows the distribution of variables included in this study, enhancing our understanding of these variables. Density plots in Figure. 5 show that the distribution of EPE and GDPPC are skewed to the right and have longer tails on the right side, indicating that a few higher values exist that pull the mean to the right. The distribution of POP is highly skewed to the right and has a longer tail on the right side. It suggests that there are some extremely large values that dominate the distribution. The UNEM distribution is almost symmetric, with a slight skew to the right. In contrast to the right-side skew of the other variables, the distribution of URB is skewed to the left, having a long tail on the left side. It indicates that there are a few lower values that are pulling the mean to the left. The skewness of the variables reflects differences in socioeconomic dynamics across the EU-27 member states.

Descriptive statistics

The descriptive statistics in Table. 2 reveal valuable insights into the variables. The mean value of EPE is 0.732, indicating a positive trend in environmental expenditure across the EU-27. However, the median value is lower than the mean, suggesting a right-skewed distribution. The range also shows significant disparities in environmental expenditure priorities among the EU-27 member states. Unlike EPE, the mean and media values of URB indicate a relatively symmetrical distribution, with a moderate variation among the countries as shown by the standard deviation.

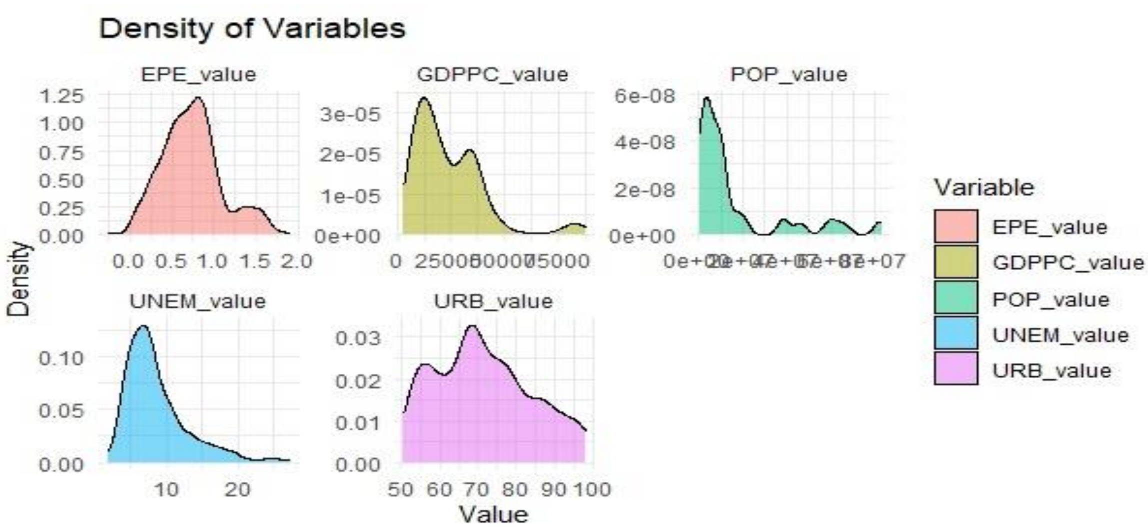

Figure 5. Density of Variables

GDPPC distribution is positively skewed as depicted by a comparison of the mean and median values. Standard deviation and range indicate a considerable economic disparity among the EU-27 countries. The UNEM mean value shows a moderately challenging employment landscape in the EU-27.

Table 2. Descriptive Statistics

Variables	Mean	Median	St. Deviation	Minimum	Maximum
EPE	0.732	0.707	0.359	-0.258	1.91
URB (%)	72.2	70.0	12.6	50.8	98.1
GDPPC ($)	24688	20670	16705	3210	88250
UNEM (%)	8.52	7.49	4.31	1.81	27.5
POP (‘000)	16322060	8391643	21465675	393028	83196078

Correlation Coefficient

Figure. 6 represents the Pearson correlation matrix, showing the relationship between EPE and the four socioeconomic indicators. The matrix shows a strong positive correlation between GDPPC and URB and a moderate positive correlation between EPE and URB. It shows that urbanization may have a moderate positive relationship on environmental expenditure. Moreover, a moderate positive correlation can be observed between POP and URB. Correlations between GDPPC and EPE, and POP and UNEM are weak.

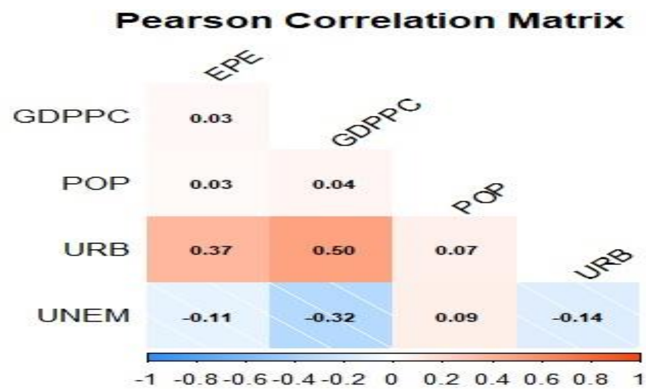

Figure 6. Pearson Correlation Matrix

Pearson correlation assumes that data points follow linear patterns (Myers et al., 2012). However, it may not accurately predict the strength of the relationship in case of non-linear relationships. Since the EKC suggests a non-linear relationship between economic growth and environmental spending, therefore, it is pertinent to examine the strength of the relationships through Spearman correlation. Moreover, the density plots show that the variables under study are not normally distributed and Spearman correlation is more appropriate in case of non-normal distribution (Schober, Boer and Schwarte, 2018).

Spearman Correlation

Spearman correlation matrix shows the relationships among five variables under study. The color scale in Figure. 7 represents the strength and direction of the correlations. The correlation matrix reveals that the most significant positive correlation is between GDPPC and URB, suggesting that as GDP per capita increases, EU-27 states experience higher levels of urbanization. Correlation between EPE and URB, and between POP and URB are moderately positive. It means that higher urbanization rates and population sizes may lead to higher environmental expenditure. Interestingly, the correlation between GDPPC and EPE, and POP and UNEM is weak, suggesting that GDP per capita may not have a direct impact on environmental expenditure. It also indicates that population growth may not have a strong impact on unemployment.

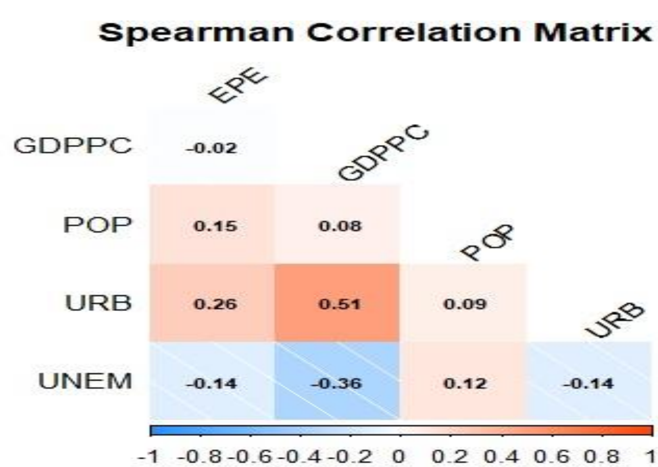

Figure 7. Spearman Correlation Matrix

A comparison of the two correlation matrices shows similar patterns. The strong positive correlation between GDPPC and URB and moderate positive correlation between EPE and URB are consistent in both Pearson and Spearman matrices.
Similarly, the correlation between GDPPC and EPE is weak in the matrices. Although the correlation between POP and URB is moderate in both matrices, it is slightly stronger in the Spearman matrix. It may show a non-linear relationship between the two variables.

Granger Causality Test

The correlation matrices provide insights into the strength and direction of the relationships between EPE and independent variables. However, correlation does not imply causality. If two variables are correlated, it does not mean that one causes the other. Therefore, it is pertinent to determine the causality through Granger causality testing, which is designed to determine whether one time series can be employed to predict another. This is crucial in cases where correlation analysis might overlook directional causality (Engle and Granger, 1987). Granger causality test is performed before regression analysis to determine the predictive relationship between EPE and the four socioeconomic variables. The rationale for employing this test lies in its ability to determine whether changes in one variable help predict changes in another variable over time (Engle and Granger, 1987). This test is relevant in economic research because understanding causal relationships can lead to informed policy and strategic decisions. Studies have used Granger causality tests to determine causal relation between export and economic growth (Jordaan and Eita, 2007), renewable energy consumption and economic growth (Aimer, 2020), CO_2 emission, energy consumption and economic growth (Akadiri and Akadiri, 2020; Gorus and Aydin, 2019). Figure. 8 reveals that GDPPC, POP and UNEM do not Granger-cause EPE with a P-value of 0.586, 0.526 and 0.809, respectively. It shows that past values of these variables may not provide ample information for predicting future values of EPE. In contrast, URB shows a statistically significant Granger-causal effect on EPE with a P-value of 0.035, implying that past urbanization levels may help predict future environmental expenditure. Moreover, it suggests that increasing urbanization may result in higher environmental expenditure.

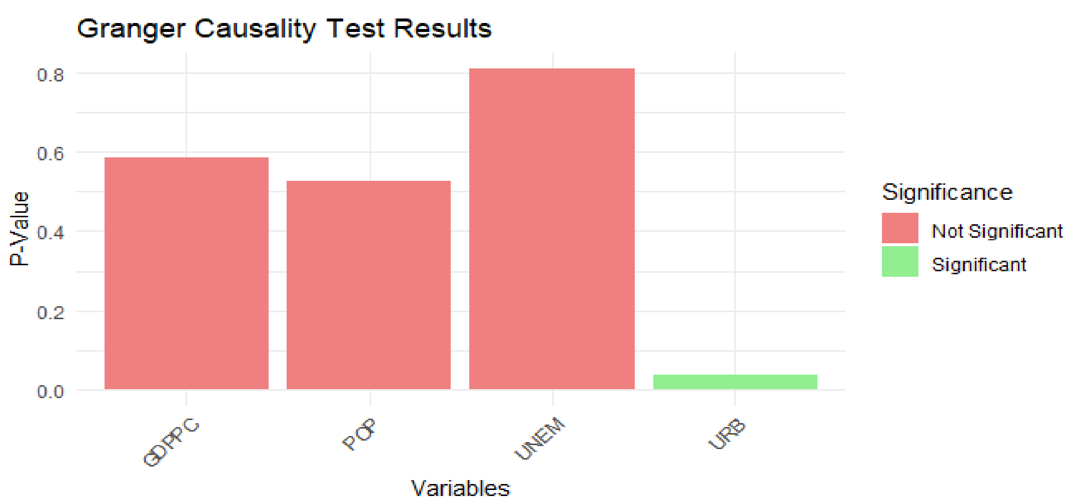

Figure 8. Granger Causality Test

After the Granger causality test, we will proceed to regression analysis, which will provide more detailed examination of how GDPPC, POP, URB and UNEM impacts environmental expenditure. It may help in identifying causal relationships and examine the factors that impact environmental expenditure.

Regression Analysis

Linear Model

Multiple linear regression analysis explores the relationship between EPE, the dependent variable and GDPPC, POP, URB and UNEW, the independent variables. The model aims to predict EPE based on the four independent variables.

Table. 3 shows the results from the linear regression model. GDPPC is significant and has a strong negative relationship with EPE, while URB has a strong positive relationship with EPE. It means that as GDPPC increases, EPE tends to decline. EPE tends to increase with an increase in urbanization rates. Al-Mulali and Ozturk (2016) and Shahbaz et al. (2013) also found that GDP is negatively associated with environmental spending especially in the long-run, while urbanization has a positive relationship with environmental expenditure.

Table 1. Regression Coefficients

Coefficients	Estimate	Std. Error	t-value	Pr (> | t |)
(Intercept)	-3.510e-02	9.168e-02	-0.383	0.70199
GDPPC	-5.385e-06	1.025e-06	-5.254	2.15e-07 ***
POP	2.610e-10	6.546e-10	0.399	0.69022
URB	1.376e-02	1.302e-03	10.571	< 2e-16 ***
UNEM	-1.031e-02	3.444e-03	-2.992	0.00289 **

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Figure 9. Linear Regression Results

The F-statistic (p-value < 2.2e-16) indicates that the model is statistically significant. It shows that the independent variables collectively explain a significant portion of the variation in EPE. The regression model also reveals that UNEM is moderately significant, indicating a negative relationship with EPE as shown in Figure. 9. It shows that higher unemployment rates are associated with lower EPE. Apergis and Ozturk (2015) also found a negative relationship between unemployment and environmental expenditure in Asia. Fodha and Zaghdoud (2010) also reported a similar trend and argued that high unemployment diverts government resources away from environmental protection. Lastly, Figure. 9 shows that the variable POP is not statistically significant, which means that population size is not a significant indicator of EPE. This finding is similar to the investigation by Apergis and Ozturk (2015) and Pellegrini and Pellegrini (2011), where they found that population density does not impact environmental spending.

Interaction Effects

GDPPC and URB, GDPPC and UNEM

The interaction model expands the regression model by incorporating interaction terms between GDPPC and URB, and GDPPC and UNEM. It enables us to examine how the relationship between EPE and independent variables varies depending on the values of the other variables.

The adjusted R-squared value is almost similar to linear regression model which shows that the interaction terms do not significantly enhance the model's explanatory power. The interaction terms between GDPPC and URB are not statistically significant. It suggests that the relationship between GDPPC and EPE does not vary significantly depending on the URB level. Similarly, the interaction term between GDPPC and UNEM is also not statistically significant, indicating that the relationship between GDPPC and EPE does not vary significantly depending on the UNEM level.

GDPPC and POP, URB and UNEM

The model is extended further by including the interaction terms between GDPPC and POP, and URB and UNEM, allowing for further examination of the way the relationships between EPE and the independent variables vary depending on the other variables' values. The interaction term between GDPPC and URB, and GDPPC and UNEM remains non-significant in this extended model as depicted in Figure. 10. Similarly, the interaction term between GDPPC and POP is also not statistically significant. It shows that the relationship between GDPPC and EPE does not vary significantly depending on the POP level. The interaction term between URB and UNEM is also not statistically significant, suggesting that the relationship between URB and EPE does not vary significantly depending on the UNEM level.

The relationship between URB and EPE remains positive and statistically significant, despite accounting for interactions with other variables. This shows that increasing urbanization rates are associated with higher EPE, irrespective of the levels of GDPPC, POP or UNEM.

The adjusted R-squared value for the linear regression model and the models with interaction terms is approximately 0.1763, indicating that this model explains approximately 17.63% is the variation in the dependent variable. It shows that the independent variables are not able to account entirely for the variation and other factors may also influence it. Another explanation is that the relationship between EPE and the independent variables might be non-linear, which could affect the accuracy of the linear model. A quadratic model might provide a better fit because it allows for a non-linear relationship between independent and dependent variables. For instance, a point of diminishing returns may reach where an increase in GDPPC or other variables beyond a certain threshold result in a decrease in EPE. A quadratic model may capture curvilinear relationships and improve the model's explanatory power.

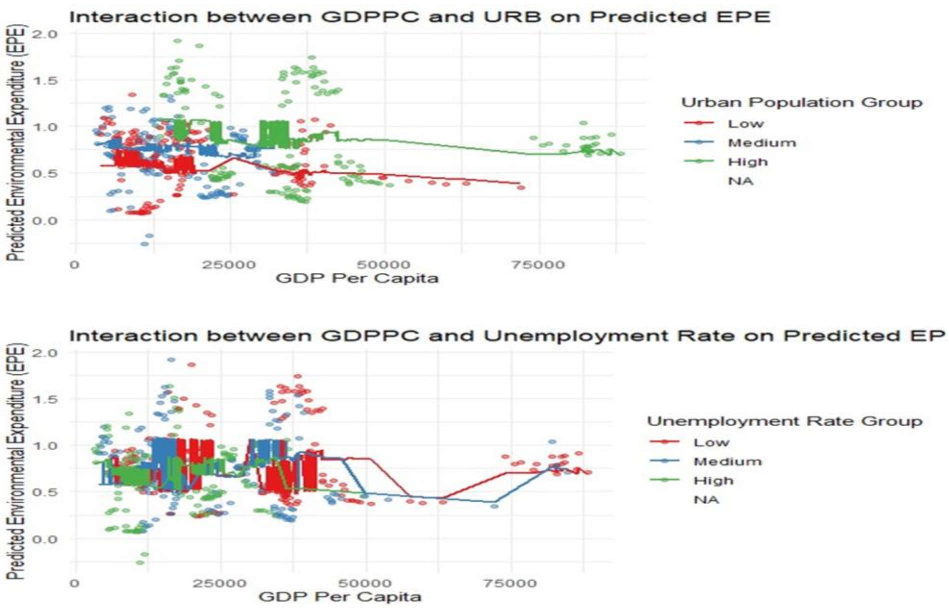

Figure 10. Interaction Effects

Table 2. Interaction Effects

Coefficients	Estimate	St. Error	t-value	Pr(>|t|)
(intercept)	-1.558e-01	3.203e-01	-0.486	0.62689
GDPPC_value	2.073e-06	8.190e-06	0.253	0.80031
URB_value	1.414e-02	4.356e-03	3.245	0.00125 **
UNEM_value	-1.123e-02	2.595e-02	-0.433	0.66546
POP_value	4.226e-09	2.773e-09	1.524	0.12815
GDPPC_value: RB_value	-3.769e-08	9.042e-08	-0.417	0.67699
GDPPC_value: UNEM_value	-6.429e-07	3.752e-07	-1.713	0.08726
GDPPC_value: POP_value	-1.285e-13	9.384e-14	-1.370	0.17134

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1
Multiple R-squared: 0.1903,
Adjusted R-squared: 0.1782
F-statistic: 15.77 on 8 and 537 DF, p-value: < 2.2e-16

Quadratic Model

The quadratic model is an extension of the linear model, incorporating squared terms for the independent variables. It helps in capturing non-linear relationships between EPE and the dependent variables.
The findings, as shown in Figure. 11 reveal that the adjusted R-squared value increased to 0.2944, indicating a substantial improvement in the model's ability to explain the variations in the environmental expenditure.

Moreover, the quadratic term for GDPPC indicates a non-linear relationship because the quadratic coefficient is positive in contrast to the negative coefficient in the linear coefficient. It shows an increasing relationship at higher levels of GDPPC. These findings resonate with the results of the quadratic model employed by Dogan et al. (2017) and Kaika and Zervas (2013) to determine the relationship between GDP and carbon emissions. These studies found that linear terms were negative, and the quadratic terms were positive. However, these studies found inverted U-shaped curves unlike this study.

The quadratic term for URB is also positive consistent with the findings by Wang et al. (2014). Interestingly, the quadratic term for POP is also significant like the linear coefficient but with opposite signs. Shao and Yang (2014) also reported a negative linear term and a positive quadratic term for population, while determining the relationship between population and environmental degradation. It shows that the relationship between EPE and POP is more complex. The quadratic term for UNEM is positive and significant in contrast to the negative coefficient of linear term which is in line with the findings by Apergis and Payne (2010).

The F-statistic (p-value < 2.2e-16) reveals that the model is highly significant and provides a better fit for the data in comparison to the linear model.

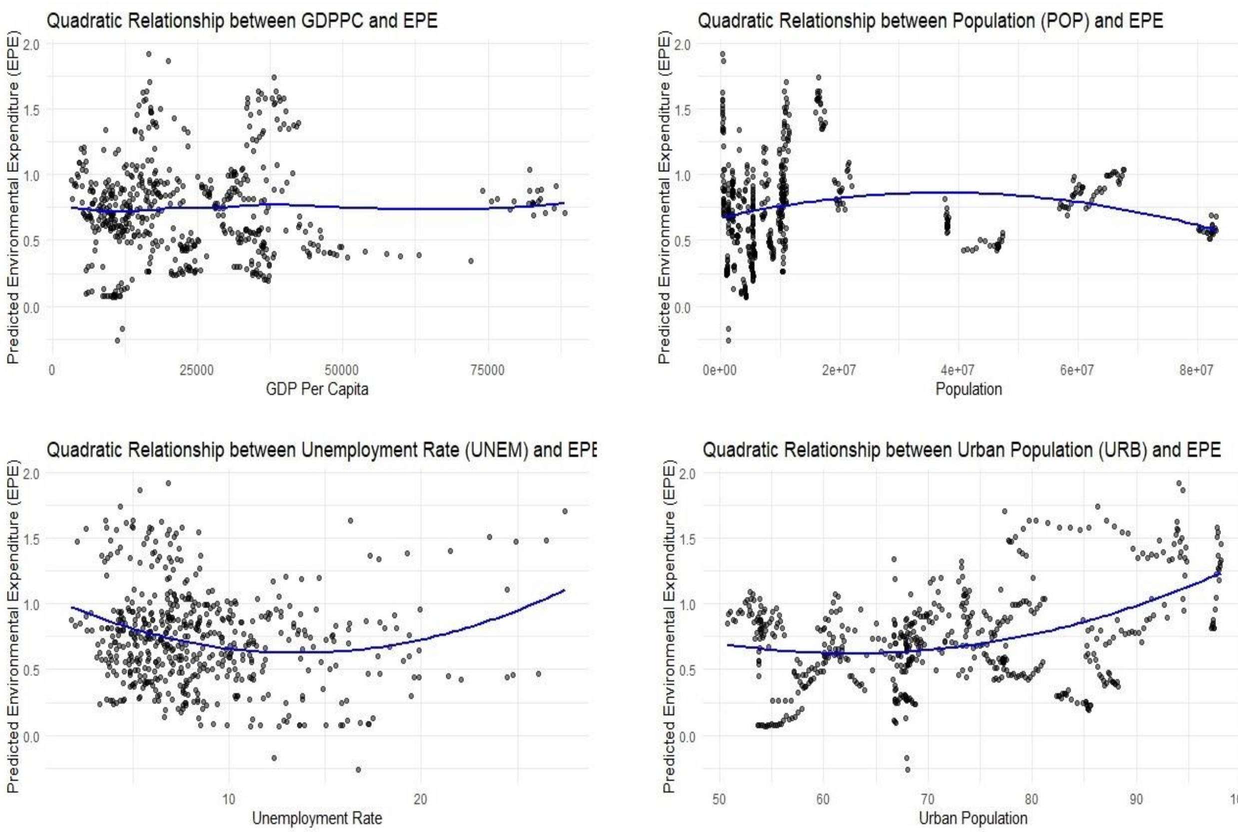

Figure 11. Quadratic Regression Model Results

The quadratic relationships between EPE and GDPPC, URB and UNEM show that increasing GDP per capita, urbanization and unemployment result in a decreased EPE initially, but after reaching a certain threshold, further increase may result in an increase in EPE. It may be due to factors like environmental regulations, technological advancements, government spending and public awareness. Unlike the suggested inverted U-shaped curve in the EKC hypothesis, the curve depicting the quadratic relationship between GDPPC and EPE appears to be more linear, indicating a consistent positive relationship. The relationship between EPE and POP is more complex and may depend on other factors.

Table 5. Quadratic Model Results

	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	3.143e+00	4.590e-01	6.847	2.07e-11 ***
GDPPC_value	-1.281e-05	2.682e-06	-4.775	2.32e-06 ***
GDPPC_squared	8.629e-11	3.111e-11	2.773	0.005739 **
URB_value	-6.783e-02	1.255e-02	-5.403	9.85e-08 ***
URB_squared	5.569e-04	8.509e-05	6.544	1.40e-10 ***
POP_value	1.077e-08	2.366e-09	4.553	6.56e-06 ***
POP_squared	-1.185e-16	3.208e-17	-3.693	0.000244 ***
UNEM_value	-6.542e-02	1.161e-02	-5.636	2.82e-08 ***
UNEM_squared	2.300e-03	4.644e-04	4.952	9.86e-07 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 0.3063 on 537 degrees of freedom
Multiple R-squared: 0.3048,   Adjusted R-squared: 0.2944
F-statistic: 29.43 on 8 and 537 DF, p-value: < 2.2e-16

Figure. 12 compares the predicted EPE from the quadratic model to the actual EPE. The scatter plot shows that the model captures the general trend in the data but does not perfectly predict individual EPE values. The data points are upward-sloping, showing that as predicted EPE increases, actual EPE also tends to increase.

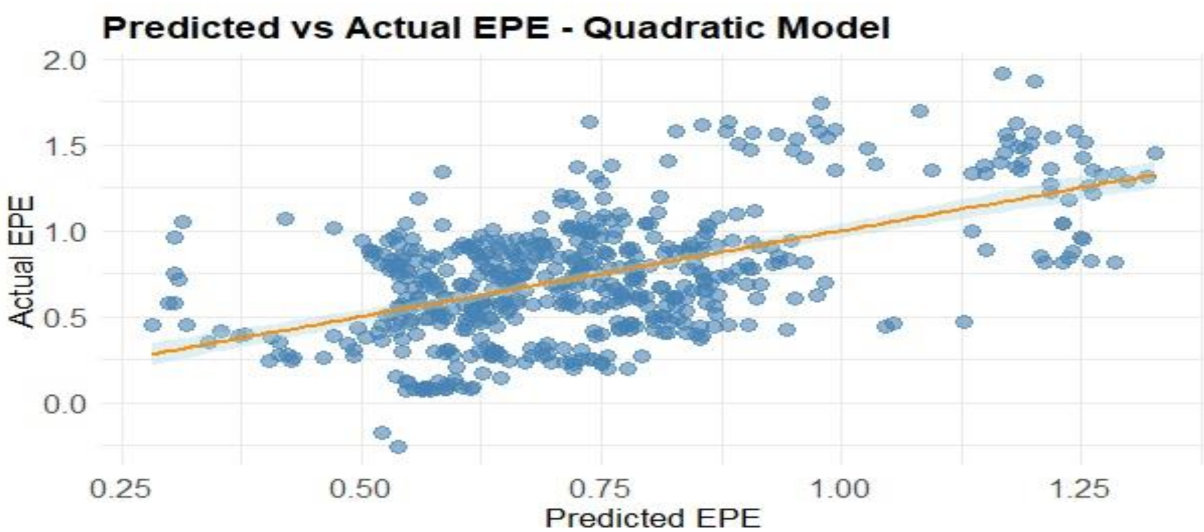

Figure 12. Predicted vs. Actual EPE (Quadratic Model)

Conclusion

This study aimed at determining the relationship between four socioeconomic indicators and environmental expenditure through a comprehensive analysis. The analysis revealed that urban population has consistent positive relation with environmental expenditure across linear and quadratic models. It implies that the EU countries with high urbanization rates tend to spend more on environmental protection initiatives. The findings showed that the relationship between GDP per capita and environmental expenditure is more linear in contrast to the inverted U-shaped expectation set by the EKC hypothesis. Although the quadratic model shows signs of non-linear relationship, the EKC's premise is still not supported. It necessitates further exploration by including factors beyond economic growth that may influence environmental expenditure. Furthermore, population size did not depict a statistically significant impact on environmental spending in both models while the unemployment rate has a negative relationship with environmental expenditure, indicating that higher unemployment rates are associated with lower environmental expenditure, possibly on account of economic constraints. The quadratic model offered a better fit for the analysis in comparison to the linear mode. However, the findings of the quadratic model suggest that although non-linear relationships exist among the variables, these may not necessarily be significant, specifically in the case of the relationship between environmental expenditure and GDP per capita. Nevertheless, the findings of this study carry important implications for policymakers. For instance, the strong positive relationship between environmental expenditure and urbanization rate reveals the importance of sustainable urban expansion in formulating environmental policies. Moreover, the lack of conclusive evidence for the EKC hypothesis reveals that policymakers need to consider the possibility that economic growth alone may not be sufficient to mitigate environmental deterioration. While this study provides valuable insights into the relationship between key socioeconomic variables and environmental expenditure, future studies may include additional variables to better understand the predictors of environmental expenditure. Furthermore, a comparison of these findings with those from other regions may shed light on the results' broader applicability. It is important to note the data's limitations and potential external factors influencing the findings of this study. Further research is needed to better understand the complex relationship between economic growth and environmental expenditure.

Declaration

Acknowledgment: N/A

Funding: N/A

Conflict of interest: N/A

Ethics approval/declaration: N/A

Consent to participate: N/A

Consent for publication: N/A

Data availability: Data available on request

Authors contribution: The author was solely involved in all aspects of this work, including the study's conceptualization and design, data collection, analysis and interpretation of results, and the preparation of the manuscript.

References

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*, *29*(28), 42539-42559. https://doi.org/10.1007/s11356-022-19718-6

Aimer, N. M. (2020). Renewable energy consumption, financial development and economic growth: evidence from panel data for the Middle East and North African countries. *Econ Bull*, *40*, 2058-2072. https://EconPapers.repec.org/RePEc:ebl:ecbull:eb-20-00439

Akadiri, S. S., & Akadiri, A. C. (2020). Interaction between CO2 emissions, energy consumption and economic growth in the Middle East: panel causality evidence. *International Journal of Energy Technology and Policy*, *16*(2), 105-118. https://doi.org/10.1504/IJETP.2020.105507

Almeida, D. V., Kolinjivadi, V., Ferrando, T., Roy, B., Herrera, H., Gonçalves, M. V., & Van Hecken, G. (2023). The "greening" of empire: The European Green Deal as the EU first agenda. *Political Geography*, *105*, 102925. https://doi.org/10.1016/j.polgeo.2023.102925

Barrell, A., Dobrzanski, P., Bobowski, S., Siuda, K., & Chmielowiec, S. (2021). Efficiency of environmental protection expenditures in EU countries. *Energies*, *14*(24), 8443. https://doi.org/10.3390/en14248443

Bhatti, U. A., Tang, H., Khan, A., Ghadi, Y. Y., Bhatti, M. A., & Khan, K. A. (2024). Investigating the nexus between energy, socio-economic factors and environmental pollution: A geo-spatial multi regression approach. *Gondwana Research*, *130*, 308-325. https://doi.org/10.1016/j.gr.2024.02.007

Bowen, A., & Hepburn, C. (2014). Green growth: an assessment. *Oxford Review of Economic Policy*, *30*(3), 407-422. http://www.jstor.org/stable/43664656.

Cagatay, S., & Mihci, H. (2006). Degree of environmental stringency and the impact on trade patterns. *Journal of economic studies*, *33*(1), 30-51. https://doi.org/10.1108/01443580610639884

Ciurea, I., & Cornelia, M. (2010). Economic disparities between EU States and Regions. *Scientific Bulletin–Economic Sciences*, *9*, 39-50. https://ideas.repec.org/a/pts/journl/y2010i1p39-50.html

Cole, M. A., & Elliott, R. J. (2003). Determining the trade–environment composition effect: the role of capital, labor and environmental regulations. *Journal of environmental economics and management*, *46*(3), 363-383. https://doi.org/10.1016/S0095-0696(03)00021-4

Collins, R. (2009). Factors related to the unemployment rate: A statistical analysis. https://scholarworks.uni.edu/hpt/9

Dalevska, N., Khobta, V., Kwilinski, A., & Kravchenko, S. (2019). A model for estimating social and economic indicators of sustainable development. *Entrepreneurship and sustainability issues*, *6*(4), 1839. https://doi.org/10.9770/jesi.2019.6.4(21)

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). Confronting the environmental Kuznets curve. *Journal of economic perspectives*, *16*(1), 147-168. http://www.jstor.org/stable/2696580.

Di Clemente, R., Strano, E., & Batty, M. (2021). Urbanization and economic complexity. *Scientific Reports*, *11*(1), 3952. 10.1038/s41598-021-83238-5

Dinda, S. (2004). Environmental Kuznets curve hypothesis: a survey. *Ecological economics*, *49*(4), 431-455. https://doi.org/10.1016/j.ecolecon.2004.02.011

Dritsaki, M., Dritsaki, C., Argyriou, V., & Sarigiannidis, P. (2024). The impact of greenhouse gas emissions and economic growth on health expenditure of EU countries: A panel data analysis. *Journal of Infrastructure, Policy and Development*, *8*(6), 4462. https://doi.org/10.24294/jipd.v8i6.4462

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276. https://doi.org/10.2307/1913236.

Ercan, H., Savranlar, B., Polat, M. A., Yıgıt, Y., & Aslan, A. (2024). The impact of technological innovations on the environmental Kuznets curve: evidence from EU-27. *Environmental Science and Pollution Research*, *31*(13), 19886-19903. https://doi.org/10.1007/s11356-024-32303-3

European Commission. (2018). *Environmental Implementation Review 2018: A Europe that Protects its Citizens and Enhances their Quality of Life*. Brussels: European Commission. Available at https://ec.europa.eu/environment/eir/pdf/full_report_en.pdf.

European Commission. (2019). *The European Green Deal*. European Commission. Available at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

European Commission. (2020). Urbanization in Europe. Available at https://knowledge4policy.ec.europa.eu/foresight/topic/continuing-urbanization/urbanization-europe_en

European Commission. (2021). *Just Transition Fund*. Commission.europa.eu. Available at https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/just-transition-fund_en

European Environment Agency (EEA). (2019). *Environmental Implementation Review 2019: A Europe that Protects its Citizens and Enhances their Quality of Life*. Brussels: European Commission. Available at https://ec.europa.eu/environment/eir/pdf/full_report_en.pdf.

Eurostat. (2021). *Environmental protection expenditure*. Retrieved from https://ec.europa.eu/eurostat

Eurostat. (2024). *Demography of Europe – 2024 Edition*. Available at https://ec.europa.eu/eurostat/web/interactive-publications/demography-2024

Fankhauser, S., Bowen, A., Calel, R., Dechezleprêtre, A., Grover, D., Rydge, J., & Sato, M. (2013). Who will win the green race? In search of environmental competitiveness and innovation. *Global Environmental Change*, *23*(5), 902-913. Working Paper. Available at https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/02/WP94-green-race-environmental-competitiveness-and-innovation.pdf

Fankhauser, S., & Stern, N. (2016). *Climate change, development, poverty and economics*. Available at https://personal.lse.ac.uk/sternn/ClimateChangeDevelopmentPoverty&Economics.Fankhauser-Stern.Oct16.pdf

Fetting, C. (2020). The European green deal. *ESDN Report*, *December*, *2*(9). Retrieved from https://www.esdn.eu/fileadmin/ESDN_Reports/ESDN_Report_2_2020.pdf

Fodha, M., & Zaghdoud, O. (2010). Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. *Energy policy*, *38*(2), 1150-1156. https://doi.org/10.1016/j.enpol.2009.11.002

Galli, A., Antonelli, M., Wambersie, L., Bach-Faig, A., Bartolini, F., Caro, D., ... & Wackernagel, M. (2023). EU-27 ecological footprint was primarily driven by food consumption and exceeded regional biocapacity from 2004 to 2014. *Nature Food*, *4*(9), 810-822. https://doi.org/10.1038/s43016-023-00843-5

Gorus, M. S., & Aydin, M. (2019). The relationship between energy consumption, economic growth, and CO2 emission in MENA countries: Causality analysis in the frequency domain. *Energy*, *168*, 815-822. https://doi.org/10.1016/j.energy.2018.11.139

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The quarterly journal of economics*, *110*(2), 353-377. https://doi.org/10.2307/2118443

Hachaichi, M., & Baouni, T. (2020). Downscaling the planetary boundaries (Pbs) framework to city scale-level: De-risking MENA region's environment future. *Environmental and Sustainability Indicators*, *5*, 100023. https://doi.org/10.1016/j.indic.2020.100023

Halkos, G. E., & Paizanos, E. A. (2013). The effect of government expenditure on the environment: An empirical investigation. *Ecological Economics*, *91*, 48-56. 10.1016/j.ecolecon.2013.04.002

Holum, M. L., & Jakobsen, T. G. (2024). Economic growth versus the environment: government spending, trust, and citizen support for environmental protection. *Environmental Sociology*, 1-12. https://doi.org/10.1080/23251042.2024.2398503

Jayachandran, S. (2022). How economic development influences the environment. *Annual Review of Economics*, *14*(1), 229-252. https://doi.org/10.1146/annurev-economics-082321-123803

Jiang, L., Young, M. H., & Hardee, K. (2008). Population, urbanization and the environment. *World Watch*, (5), 34-39. Available at https://www.wilsoncenter.org/sites/default/files/media/documents/event/Hardee1.pdf

Jordaan, A. C., & Eita, J. H. (2007). Export and economic growth in Namibia: a Granger causality analysis. *South African Journal of Economics*, *75*(3), 540-547. 10.1111/j.1813-6982.2007.00132.x

Kammen, D. M. (2008). Putting renewables to work: how many jobs can the clean energy industry generate? DIANE Publishing. Available at https://rael.berkeley.edu/old_drupal/sites/default/files/old-site-files/2004/Kammen-Renewable-Jobs-2004.pdf

Kazak, T. (2020). European green deal. *Yearbook of the law department*, *9*(10), 304-315. https://doi.org/10.33919/yldnbu.20.9.12

Le Gallo, J., & Ndiaye, Y. (2021). Environmental expenditure interactions among OECD countries, 1995–2017. *Economic Modelling*, *94*, 244-255. https://doi.org/10.1016/j.econmod.2020.10.006

Leiter, A. M., Parolini, A., & Winner, H. (2011). Environmental regulation and investment: Evidence from European industry data. *Ecological Economics*, *70*(4), 759-770. https://doi.org/10.1016/j.ecolecon.2010.11.013

Lenaerts, K., Tagliapietra, S., & Wolff, G. B. (2022). How can the European Union adapt to climate change? *Intereconomics*, *57*(5), 314-321. https://doi.org/10.1007/s10272-022-1071-4

Liang, L., Wang, Z., & Li, J. (2019). The effect of urbanization on environmental pollution in rapidly developing urban agglomerations. *Journal of cleaner production*, *237*, 117649. https://doi.org/10.1016/j.jclepro.2019.117649

Liddle, B. (2017). *The urbanization, development, environment, and inequality nexus: Stylized facts and empirical relationships* (No. 788). ADBI Working Paper. https://www.adb.org/publications/urbanization-development-environment-and-inequality-nexus

Liu, Y. Q., & Feng, C. (2022). The effects of nurturing pressure and unemployment on carbon emissions: Cross-country evidence. *Environmental Science and Pollution Research*, *29*(34), 52013-52032. 10.1007/s11356-022-19515-1

Martınez-Zarzoso, I., & Bengochea-Morancho, A. (2004). Pooled mean group estimation of an environmental Kuznets curve for CO2. *Economics letters*, *82*(1), 121-126. 10.1016/j.econlet.2003.07.008

Meyer, A. (2016). Is unemployment good for the environment? *Resource and Energy Economics*, *45*, 18-30. https://doi.org/10.1016/j.reseneeco.2016.04.001

Mohammed, S., Gill, A. R., Ghosal, K., Al-Dalahmeh, M., Alsafadi, K., Szabó, S., ... & Harsanyi, E. (2024). Assessment of the environmental Kuznets curve within EU-27: Steps toward environmental sustainability (1990–2019). *Environmental Science and Ecotechnology*, *18*, 100312. https://doi.org/10.1016/j.ese.2023.100312

Mourre, G. (2009). *What explains the differences in income and labour utilisation and drives labour and economic growth in Europe? A GDP accounting perspective* (No. 354). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission. Available at https://ec.europa.eu/economy_finance/publications/pages/publication13796_en.pdf

Mulita, R. (2022). Driving the EU green deal through innovative university curricula on circular economy. *CRJ*, (2), 11-14. https://doi.org/10.59380/crj.v1i1.637

Myers, R. H., Montgomery, D. C., Vining, G. G., & Robinson, T. J. (2012). *Generalized linear models: with applications in engineering and the sciences*. John Wiley & Sons. 10.1002/9780470556986

Neagu, O., Ardelean, D. I., & Lazăr, V. (2017). How is environmental performance associated with economic growth? A world cross-country analysis. *Studia universitatis „vasile goldis" arad–economics series*, *27*(3), 15-32. 10.1515/sues-2017-0010

Niu, B. (2024). Government environmental protection expenditure and national ESG performance: Global evidence. *Innovation and Green Development*, *3*(2), 100117. https://doi.org/10.1016/j.igd.2023.100117

Phoomsavarth, M. (2023). The Potential of European Green Deal Taxation as a New Approach for Promoting Environmental Sustainability and Economic Development in the European Union. In *Proceedings of the Central and Eastern European eDem and eGov Days 2023* (pp. 198-203). https://doi.org/10.1145/3603304.3603349

Pollin, R., Heintz, J., & Garrett-Peltier, H. (2014). The economic benefits of investing in clean energy. *Center for American Progress and Political Economy Research Institute*. Available at https://cdn.americanprogress.org/wp-content/uploads/issues/2009/06/pdf/peri_report_execsumm.pdf

Romano, B., Sette, C., Zullo, F., & Montaldi, C. (2023). Landscape Profiles, Urbanization and Environmental Protection in Europe: Is Western the Future Scenario for Eastern? *Current Urban Studies*, *11*(2), 301-318. 10.4236/cus.2023.112016

Rosiek, J. (2013). The impact of the EU climate policy on green jobs creation. *Economics and Management*, *18*(4), 697-714. 10.5755/j01.em.18.4.4498.

Ruiz, J., Martin-Moreno, J. M., & Perez, R. (2023). Mid-term policy considerations of the EU green deal. *Energy Strategy Reviews*, *50*, 101239. https://doi.org/10.1016/j.esr.2023.101239

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia & analgesia*, *126*(5), 1763-1768. 10.1213/ANE.0000000000002864

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and sustainable energy reviews*, *25*, 109-121. https://doi.org/10.1016/j.rser.2013.04.009

Singh, S., Shukla, A., & Jain, K. (2024). Assessing the urbanization-induced impact on environmental parameters of a city from a remote-sensing perspective. *Remote Sensing Applications: Society and Environment, 34,* 101169. https://doi.org/10.1016/j.rsase.2024.101169

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World development*, *32*(8), 1419-1439. https://doi.org/10.1016/j.worlddev.2004.03.004

Stern, D. I. (2018). The environmental Kuznets curve. In *Companion to Environmental Studies* (pp. 49-54). Routledge. Available at https://www.taylorfrancis.com/chapters/edit/10.4324/9781315640051-11/environmental-kuznets-curve-david-stern

Suhányi, L., Suhányiová, A., & Kočišová, M. (2023). Renewable Energy Consumption in the Context of Economic Development, CO 2 Emissions and Implications for Public Administration: The Case of Visegrad Group Countries. *Acta Montanistica Slovaca*, *28*(4). https://doi.org/10.46544/AMS.v28i4.14

Upreti, P. (2015). Factors affecting economic growth in developing countries. *Major Themes in Economics*, *17*(1), 37-54. https://scholarworks.uni.edu/mtie/vol17/iss1/5

Verbič, M., Satrovic, E., & Muslija, A. (2021). Environmental Kuznets curve in Southeastern Europe: the role of urbanization and energy consumption. *Environmental Science and Pollution Research*, *28*(41), 57807-57817. https://doi.org/10.1007/s11356-021-14732-6

Wang, Q., Wang, X., & Li, R. (2022). Does urbanization redefine the environmental Kuznets curve? An empirical analysis of 134 Countries. *Sustainable Cities and Society*, *76*, 103382. https://doi.org/10.1016/j.scs.2021.103382

Weber, H., & Sciubba, J. D. (2019). The effect of population growth on the environment: evidence from European regions. *European Journal of population*, *35*, 379-402. 10.1007/s10680-018-9486-0

Yip, C. M. (2018). On the labor market consequences of environmental taxes. *Journal of Environmental Economics and Management*, *89*, 136-152. https://doi.org/10.1016/j.jeem.2018.03.004

Zhao, Y., Wang, S., Ge, Y., Liu, Q., & Liu, X. (2017). The spatial differentiation of the coupling relationship between urbanization and the eco-environment in countries globally: A comprehensive assessment. *Ecological modelling*, *360*, 313-327. https://doi.org/10.1016/j.ecolmodel.2017.07.009