

# ROLE OF THE STATE IN THE PREVENTION OF ENVIRONMENTAL POLLUTION: EMPIRICAL EVIDENCE FOR THE COUNTRIES OF THE WESTERN BALKANS

## *ROLUL STATULUI ÎN PREVENIREA POLUĂRII MEDIULUI: DOVEZI EMPIRICE PENTRU ȚĂRILE DIN BALCANII DE VEST*

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**Abstract:** *This study aims to investigate the role of the state in preventing environmental pollution in the Western Balkans, focusing on the impact of state policies, such as institutional quality, environmental taxation, and regulatory frameworks, on reducing pollution levels in the Western Balkans. Using panel data from 2010-2023 and econometric models, it finds that renewable energy ( $B = -0.461, p < 0.001$ ), institutional quality ( $B = -0.344, p < 0.01$ ), and carbon taxes ( $B = -0.343, p < 0.001$ ) significantly lower CO<sub>2</sub> emissions. Trade and regulatory quality reduce energy consumption ( $B = -0.481, p < 0.05$ ;  $B = -0.0415, p < 0.05$ ), though trade increases PM<sub>2.5</sub> pollution ( $B = 0.261, p < 0.01$ ). Strong institutions enhance energy efficiency ( $B = 0.139, p < 0.05$ ), highlighting effective state interventions.*

**Keywords:** Environmental Pollution, Renewable Energy, Institutional Quality, Carbon Tax, Air Pollution.

**Rezumat:** *Acest studiu își propune să investigheze rolul statului în prevenirea poluării mediului în Balcanii de Vest, concentrându-se pe impactul politicilor de stat, cum ar fi calitatea instituțională, impozitarea mediului și cadrele de reglementare, asupra reducerii nivelurilor de poluare în Balcanii de Vest. Folosind date panel din 2010-2023 și modele econometrice, se constată că*

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*energia regenerabilă (B= -0,461, p<0,001), calitatea instituțională (B= -0,344, p<0,01) și taxele pe carbon (B= -0,343, p<0,001) scad semnificativ emisiile de CO<sub>2</sub>. Comerțul și calitatea reglementărilor reduc consumul de energie (B= -0,481, p< 0,05; B= -0,0415, p< 0,05), deși comerțul crește poluarea cu PM<sub>2,5</sub> (B= 0,261, p< 0,01). Instituții puternice sporesc eficiența energetică (B= 0,139, p< 0,05), evidențiind intervențiile eficiente ale statului.*

**Cuvinte cheie:** Poluarea mediului, Energie regenerabilă, Calitate instituțională, Taxa pe carbon, Poluarea aerului.

## 1. Introduction

Environmental pollution has emerged as one of the most pressing challenges for countries worldwide, particularly in regions undergoing rapid industrialization and urbanization. The Western Balkans, a region characterized by diverse economies, varying levels of development, and shared environmental concerns, faces significant pollution-related challenges that threaten the health and well-being of its population. The state's role in mitigating and preventing environmental pollution is critical, as government policies and interventions can greatly influence the success of environmental protection efforts (Chang et al., 2019). The importance of state-led initiatives in environmental governance has been emphasized in numerous studies, particularly in addressing air and water pollution, waste management, and the regulation of industrial emissions (Bulkeley & Newell, 2010).

The countries of the Western Balkans, including Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia, have historically faced environmental degradation, which has been exacerbated by industrial activity, inadequate waste management systems, and insufficient environmental regulations (Knez et al., 2022). As the region strives for European Union integration, addressing environmental pollution has become a critical component of its political and economic reform process. However, the region's ability to balance economic growth with environmental sustainability has often been hindered by weak institutional frameworks, limited financial resources, and political instability (Jungwirth, 2015).

Existing literature primarily focuses on the environmental challenges facing individual countries in the region, yet there is a lack of comparative research examining the role of the state in environmental pollution prevention across the entire Western Balkans. This gap in research presents an opportunity to explore the effectiveness of state-led policies and the challenges faced by governments in this context (Kujundzic, 2012; Thomas & Bojicic-Dzelilovic,

2014). Despite the increasing awareness of environmental issues in the region, the implementation of effective policies remains inconsistent, and environmental laws are often poorly enforced, particularly in less developed or rural areas.

The research questions for this study is as follows: (i) What is the role of the state in the prevention of environmental pollution in the countries of the Western Balkans? To address this questions, the following hypothes is proposed: H<sub>1</sub>: The effectiveness of environmental policies in the Western Balkans is influenced by the strength of institutional frameworks and political stability.

To test these hypotheses, quantitative methods will be employed. This will include a comparative analysis of national environmental policies across the Western Balkans, as well as statistical analysis of pollution levels. Panel data models, including Fixed and Random Effects approaches, will be applied to analyze the relationship between policy interventions and environmental outcomes. Data will be sourced from both international environmental databases and national governmental agencies to ensure the accuracy and comprehensiveness of the study.

This paper is of particular importance, as it is the only one that empirically examines the impact of the state on reducing environmental pollution in the Western Balkan countries. In the context of global and regional environmental challenges, this research fills an important gap in the scientific literature, serving as a basis for more effective and sustainable policies for environmental protection in this region.

The structure of the paper is as follows: the second section provides a review of the literature on environmental pollution prevention, highlighting relevant theoretical frameworks and empirical findings. The third section outlines the research methodology, detailing the data sources and econometric techniques used in the study. The fourth section presents the empirical results, including a discussion of the effectiveness of state interventions in mitigating environmental pollution in the Western Balkans. Fifth section concludes the paper, summarizing the findings and offering recommendations for improving environmental governance in the region.

## **2. Literature Review**

Seto et al. (2016) examine the concept of carbon lock-in, which refers to the inertia of carbon emissions resulting from the interplay of physical, economic, and social constraints. These constraints, including large capital costs, long infrastructure lifetimes, and interdependencies between socioeconomic and technical systems, create significant challenges for

reducing emissions. The study identifies three primary types of carbon lock-in (a) infrastructural and technological, (b) institutional, and (c) behavioral and highlights their coevolution and interconnectedness in reinforcing emissions inertia. The authors synthesize existing literature to evaluate the scale, magnitude, longevity, and policy implications of carbon lock-in, emphasizing its urgency in the context of mitigating dangerous climate change. They propose strategies for transitioning to less-carbon-intensive pathways and outline a research agenda to address knowledge and policy gaps, fostering better integration between science and policymaking.

Shahbaz et al. (2013) investigate whether financial development contributes to reducing CO<sub>2</sub> emissions in Malaysia. Using the bounds testing approach to cointegration, they find significant long-run relationships between CO<sub>2</sub> emissions, financial development, energy consumption, and economic growth. The results suggest that financial development helps reduce CO<sub>2</sub> emissions, while energy consumption and economic growth increase them. Granger causality analysis supports the feedback hypothesis, indicating bidirectional causality between financial development and CO<sub>2</sub> emissions, energy consumption and CO<sub>2</sub> emissions, and CO<sub>2</sub> emissions and economic growth. The study highlights the nuanced role of financial development in addressing environmental challenges in Malaysia.

Tamazian and Rao (2010) explore the relationship between economic development, financial development, institutional quality, and environmental degradation in 24 transition economies over the period 1993–2004. Addressing gaps in earlier studies, such as issues of endogeneity and omitted variables, the authors use a reduced-form modeling approach and GMM estimation techniques. Their findings support the Environmental Kuznets Curve (EKC) hypothesis, suggesting that economic growth initially increases environmental degradation before leading to improvements at higher income levels. Additionally, the study highlights the crucial role of institutional quality and financial development in enhancing environmental performance. Authors caution that financial liberalization can negatively impact environmental quality if not implemented within a robust institutional framework.

Beka et al. (2024) investigate the impact of economic, financial, and institutional developments on CO<sub>2</sub> emissions, focusing on a comparative analysis between 38 OECD countries and 5 Western Balkan countries from 2010 to 2022. Using secondary data and panel regression methods, including OLS, fixed effects, random effects, and the Hausman–Taylor instrumental variable model, the study identifies key factors influencing CO<sub>2</sub> emissions.

Results highlight the significant roles of inflation, business freedom, and political stability. The study contributes to the literature by introducing a unique dataset and methodology for a specific period and offering a comparative perspective on the distinct economic, social, and environmental dynamics of the OECD and Western Balkan regions. This approach provides valuable insights for policymakers aiming to design effective environmental strategies.

Amxhekaj et al. (2024) examine the role of institutional quality in accelerating the energy transition and its effects on economic growth in the Western Balkans. Recognizing the region's dependence on energy and its implications for GDP growth, the study highlights the necessity of institutional reforms to enhance energy efficiency, reduce pollution, and decrease reliance on imports. Using data from the World Development Indicators and the International Energy Agency (2005–2020), the authors apply random and fixed effects regression models to explore the interplay between institutions, energy transition, and economic growth. Key findings reveal that governance effectiveness, trade openness, and CO<sub>2</sub> emissions positively influence total energy consumption, while corruption control and political stability negatively impact energy efficiency and GDP per capita. The study emphasizes that renewable energy consumption fosters both GDP growth and GDP per capita, underscoring the critical role of institutional reforms in supporting sustainable energy transitions.

Gara et al. (2024) investigate the relationship between energy use and air pollution in OECD countries, emphasizing the environmental implications of energy consumption patterns in developed nations. Using panel data spanning from 2010 to 2021 (456 observations), the study examines variables such as per capita energy use, renewable energy production, greenhouse gas emissions, and energy imports. The analysis employs econometric techniques including OLS, OLS Robust, fixed, and random effects models. Findings indicate that increased electricity use and CO<sub>2</sub> emissions significantly deteriorate air quality. However, energy sourced from renewables (water, wind, nuclear, and geothermal) mitigates air pollution, underlining the role of sustainable energy in addressing environmental challenges. The study provides actionable insights for policymakers in OECD nations to prioritize renewable energy in combating air pollution.

Yurtsever and Uçar (2014) examine the role and importance of tax policies in preventing environmental pollution, focusing on the application of environmental taxes such as green, carbon, emission, and pollution taxes. The study outlines the contributions of environmental taxes in various countries

and compares their implementations with those in Turkey. It also highlights the shortcomings in Turkey's approach to environmental taxation and explores theoretical perspectives on the subject. The authors emphasize that environmental taxes aim to hold those responsible for environmental degradation accountable, rather than primarily increasing public revenue, which underscores the growing importance of these policies in addressing pollution.

The studies reviewed provide compelling evidence of the significant role that China's Environmental Protection Tax (EPT) Law plays in reducing pollution and enhancing residents' well-being. Liu et al. (2019) demonstrate that environmental taxes help mitigate the harmful effects of air and water pollution on residents' happiness, particularly in areas with higher tax rates. This finding aligns with the broader body of research on the environmental tax's impact, as Xu et al. (2023) and Yang et al. (2024) highlight how the policy reduces emissions of pollutants such as sewage, waste gases, SO<sub>2</sub>, and CO<sub>2</sub>. These studies underscore the importance of environmental taxation in improving environmental quality and, by extension, public health and well-being. The synergistic effects of pollution and carbon reduction, as shown in Yang et al. (2024) and Gao et al. (2022), further emphasize the potential of environmental taxes to simultaneously tackle multiple environmental challenges, contributing to both pollution reduction and carbon mitigation.

These studies share a common focus on the mechanisms driving the effectiveness of environmental taxes. Xu et al. (2023) identify three key mechanisms: internalizing external costs, promoting green innovation, and stimulating environmental protection infrastructure, which are also reflected in the findings of Yang et al. (2024) and Gao et al. (2022). The latter studies highlight the role of energy structure optimization, green technology innovation, and environmental supervision in enhancing the synergy between pollution reduction and carbon reduction. Additionally, the heterogeneity of policy effects, as discussed in these studies, points to the importance of region-specific factors, such as tax rates and governmental scales, in shaping the outcomes of environmental tax policies.

### **3. Methodology**

The methodology used to examine the role of the state in preventing environmental pollution in the countries of the Western Balkans is quantitative and relies on secondary data. The research encompasses a total of 6 countries in the region (Kosovo, Albania, Montenegro, Bosnia and

Herzegovina, North Macedonia, and Serbia). To analyze the data effectively, the study applies a range of econometric models. Initially, the research uses basic Ordinary Least Squares (OLS) regression to capture the general relationship between state policies and environmental pollution levels. Additionally, the study employs the Ordinary Least Squares Robust (OLSR) model to account for potential heteroscedasticity or other issues that might violate OLS assumptions.

Since the data is panel, meaning it includes observations across multiple countries and years, the study incorporates two other econometric methods: Fixed Effects (FE) and Random Effects (RE) models. The Fixed Effects model is used to account for unobserved country-specific characteristics that could influence pollution levels, ensuring that the analysis captures the impact of variables that vary over time within each country (Bell & Jones, 2015). Random Effects model is applied to estimate the impact of both observed and unobserved variables while assuming that the unobserved country-specific factors are uncorrelated with the independent variables (Clark & Linzer, 2015). The use of these various models allows for a comprehensive understanding of how governmental policies across different Western Balkan countries contribute to the prevention of environmental pollution, while also testing for the robustness and reliability of the results.

The methodology employed to analyze the role of the state in preventing environmental pollution in the countries of the Western Balkans spans a 14-year period, with data covering the years 2010 to 2023. The study focuses on six countries in the region: Kosovo, Albania, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. Given the research design, the data used in the analysis is panel data, which includes observations over time across multiple countries. This results in a total of 84 observations for the six countries over the 14-year period.

The use of advanced panel data models, specifically the Fixed Effects (FE) and Random Effects (RE) models, is well-suited to the structure of the dataset in this study. With data covering six countries over a 19-year period, these models effectively address the high variability present within the dataset. The Fixed Effects (FE) model, in particular, is valuable because it allows for the examination of time-invariant characteristics unique to each country. These characteristics may influence the environmental pollution outcomes but are not explicitly included in the model. The FE model effectively controls for this heterogeneity by accounting for factors that remain constant within each country over time, thus minimizing potential bias caused by omitted variables.

As noted by Greene (2000), the FE model is especially appropriate for analyzing panel data when the primary interest lies in understanding the impact of time-varying variables within each economic entity. In this study, this refers to examining the role of government policies and their dynamic effects on environmental pollution. By isolating the effects of variables that change over time, such as policy decisions, the FE model enables a more accurate assessment of the relationship between state intervention and pollution reduction. This method ensures that any unobserved country-specific factors that could influence environmental outcomes, but are not captured by the model, do not distort the analysis. Therefore, the FE model offers a robust approach to understanding how changes in state policies over time contribute to environmental protection efforts in the Western Balkans.

The Random Effects (RE) model plays a crucial role in this study, particularly for analyzing high variations across countries. The RE model operates under the assumption that unobserved heterogeneity is uncorrelated with the independent variables, which is an essential condition for its effectiveness. This method is especially valuable in cross-country studies like this one, as it assumes that country-specific effects are randomly distributed rather than fixed. This allows the RE model to capture both within-country variations (changes over time within each country) and between-country variations (differences across countries).

As highlighted by Baltagi (2021), the RE model is particularly efficient when there is no correlation between the random effects and the explanatory variables. In such cases, it provides a more generalized understanding of the data, reflecting both individual country dynamics and the broader cross-country differences. Additionally, the RE model serves as an important complement to the Fixed Effects (FE) model, offering an alternative perspective on the data. By incorporating the RE model, the study can conduct robustness checks and comparative analyses, ensuring a comprehensive evaluation of the role of state intervention in reducing environmental pollution across the Western Balkans. As Baltagi (2009) points out, the RE model's ability to account for random variations adds depth to the analysis, making it a key tool for cross-country research.

To determine the most appropriate and reliable model for this study, the Hausman test was employed. The Hausman test is commonly used to compare fixed effects (FE) and random effects (RE) models, helping to assess which model best fits the data structure. Hausman and Taylor (1981) emphasize the importance of this test in ensuring the validity of panel data analysis, as it identifies whether the unobserved heterogeneity is correlated

with the independent variables. If the test suggests that the fixed effects model is more appropriate, it indicates that the model accounts for important time-invariant characteristics of the entities being studied, which are likely to influence the dependent variable. On the other hand, if the test favors the random effects model, it implies that the unobserved heterogeneity is uncorrelated with the independent variables and that the model is more efficient in explaining the variations across entities.

The Hausman test is an integral tool in robust econometric modeling, particularly in studies that involve policy analysis over time and across multiple entities, such as examining the impact of monetary policy on inflation. By guiding the selection between FE and RE models, the test ensures that the most suitable model is chosen for accurately capturing the relationships within the data, thereby enhancing the reliability and validity of the results. The use of this test strengthens the methodological foundation of the study and ensures that the conclusions drawn are well-supported by the data.

*Table 1. Results of the Pesaran-Shin Unit-Root Test for Stationarity of Variables*

Variable	t-bar	p-value
CO2C	-2.75	0.008
CO2	-3.42	0.000
TRA	-3.87	0.000
PSI	-3.98	0.001
RQI	-2.19	0.031
CC	-2.09	0.018
REC	-2.18	0.001
QI	-2.028	0.023
EUPC	-2.13	0.004
RLI	-4.76	0.000
GEI	-3.078	0.000
CT	-3.76	0.000
PM25	-4.98	0.000

Table 1 presents the results of the Pesaran-Shin Unit-Root Test, assessing the stationarity of various variables. The t-bar statistics and corresponding p-values indicate that all variables reject the null hypothesis of a unit root at conventional significance levels ( $p \leq 0.05$ ), suggesting they are

stationary. Specifically, variables such as CO<sub>2</sub> (-3.42, p = 0.000), TRA (-3.87, p = 0.000), PSI (-3.98, p = 0.001), RLI (-4.76, p = 0.000), and PM<sub>2.5</sub> (-4.98, p = 0.000) exhibit particularly strong evidence of stationarity with highly significant p-values and more negative t-bar statistics, implying robust stability in their time series properties. Other variables, including CO<sub>2</sub>C (-2.75, p = 0.008), RQI (-2.19, p = 0.031), CC (-2.09, p = 0.018), REC (-2.18, p = 0.001), QI (-2.028, p = 0.023), EUPC (-2.13, p = 0.004), GEI (-3.078, p = 0.000), and CT (-3.76, p = 0.000), also demonstrate stationarity, though with varying degrees of statistical significance. These findings suggest that the variables are suitable for further econometric analysis without requiring differencing to achieve stationarity.

The specification of the models is as follows:

$$CO2it = B0 + \beta1(Tradeit) + \beta2(PSIit) + \beta3(RQIit) + \beta4(CCit) + \beta5(RECit) + \beta6(QIit) + \beta7(EnergyUsePCit) + \beta8(RoLit) + \beta9(GEIt) + \beta10(CTit) + \beta11(PM25it) + \epsilon it \quad (1)$$

$$EnergyUsePCit = \mu + \beta1(CO2it) + \beta2(Tradeit) + \beta3(PSIit) + \beta4(RQIit) + \beta5(CCit) + \beta6(RECit) + \beta7(QIit) + \beta8(RoLit) + \beta9(GEIt) + \beta10(CTit) + \beta11(PM25it) + \epsilon it \quad (2)$$

$$PM25it = \mu + \beta1(CO2it) + \beta2(Tradeit) + \beta3(PSIit) + \beta4(RQIit) + \beta5(CCit) + \beta6(RECit) + \beta7(QIit) + \beta8(EnergyUsePCit) + \beta9(RoLit) + \beta10(GEIt) + \beta11(CTit) + \epsilon it \quad (3)$$

The equations represents an empirical regression model where the dependent variable is a specified environmental or economic indicator, and the model estimates how this outcome is influenced by three key independent variables. The first independent variable, CO<sub>2</sub> emissions (CO<sub>2</sub>), represents the level of carbon dioxide emissions, which can be a significant factor in environmental and economic outcomes. The second independent variable, Energy Use Per Capita, reflects the total energy consumption per person within a country, which can impact both economic growth and environmental sustainability. The third independent variable, the PM 2.5 air pollution index (PM 2.5), indicates the concentration of particulate matter in the air, a critical factor affecting public health and environmental quality. The error term ( $\epsilon_{it}$ ) accounts for unobserved factors that may affect environmental pollution, but are not represented as independent variables in the equation presented.

Table 2. Description of research variables

Variable	Abbreviation	Unit	Data Source
CO2 Emissions	CO2	Thousands of tonnes	World Bank
CO2 Emissions Per Capita	CO2C	Thousands of tonnes/population	The Global Economy
Energy Use Per Capita	EUPC	Kwh per Capita	The Global Economy
PM 2.5 air pollution	PM25	Numeric	World Bank
Rule of law index	RLI	-2.5 – 2.5	The Global Economy
Government effectiveness index	GEI	2.5 – 2.5	The Global Economy
Control of corruption	CC	2.5 – 2.5	The Global Economy
Regulatory quality index	RQI	2.5 – 2.5	The Global Economy
Political stability index	PSI	2.5 – 2.5	The Global Economy
Carbon Tax	CT	%	World Bank & Our World in Data
Trade	TRA	% of GDP	World Bank
Renewable Energy Consumption	REC	% of total energy use	The Global Economy
Quality of Institutions	QI	Average of CC, RQI, GEI and PSI	Generated by Authors

#### 4. Results

Table 3 presents the descriptive statistics of the variables used in the study, for 84 observations of several key variables related to institutional quality, CO2 emissions, energy use and air pollution

The average of total CO2 emissions (CO2) is 15,299.75 thousand tons, with a standard deviation of 15.79, indicating a large variation between the countries analyzed. Per capita emissions (CO2C) have a smaller average of 4,443 thousand tons per capita, reflecting significant differences in use and environmental impact between countries. For air pollution, PM2.5 particulate pollution has an average of 31,187 units, with some countries reaching extreme levels of up to 326.43 units.

Institutional quality (QI), an average of other institutional indicators such as control of corruption (CC), government effectiveness (GEI), regulatory quality (RQI) and political stability (PSI), has a mean of 15.34, with a standard deviation of 5.39. Control of corruption (CC) has a mean of 38.42 and a relatively small standard deviation of 4.16, suggesting limited variability. In contrast, indicators such as regulatory quality (RQI) and

political stability (PSI) have low mean values and a larger standard deviation, indicating greater challenges in these areas.

Energy use per capita (EUPC) has a mean of 1.47 kWh, suggesting moderate consumption on average in the countries included. The share of renewable energy in total energy consumption (REC) is 29.76%. Trade (TRA), as a percentage of GDP, has an average of 98.62%, which suggests a high dependence of economies on international trade.

*Table 3. Descriptive statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2C	84	4.443	1.668	1.21	7.08
CO2	84	15299.75	15792.998	2150	53342
TRA	84	98.628	21.494	59.83	170.2
PSI	84	-.202	.376	-1.04	.6
RQI	84	7.581	16.876	-.18	52.13
CC	84	38.429	4.163	28	47
REC	84	29.764	10.138	14.16	56.71
QI	84	15.349	5.398	10.385	28.802
EUPC	84	1.472	.391	.91	2.4
RLI	84	-.129	.209	-.52	.32
GEI	84	-.022	.448	-1.04	1.02
CT	84	1.646	1.32	0	4.32
PM25	84	31.187	33.015	18.19	326.43

Table 4 presents the averages of the main economic indicators for each of the 6 member states of Western Balkans during the period under study. The regional average for CO2 emissions per capita is 4.44 thousand tons, with Bosnia and Herzegovina and Serbia significantly exceeding this average (6.36 and 5.97, respectively). Albania has the lowest level of emissions per capita (1.59), reflecting a lower environmental impact from this country. For total CO2 emissions, Serbia leads with 47,448.14 thousand tons, which is much higher than the regional average of 15,299.75 thousand tons, while Montenegro has the lowest level of 2,513.64 thousand tons.

For air pollution with PM 2.5 particles, the regional average is 31.19, with Serbia recording the highest level of 49.69, suggesting significant environmental problems in this country. Albania has the lowest pollution (20.08), indicating better air quality compared to other countries in the region. In terms of energy use per capita (EUPC), the regional average is 1.47 kWh,

with Serbia having the highest consumption (1.92) and Albania having the lowest consumption (1.24).

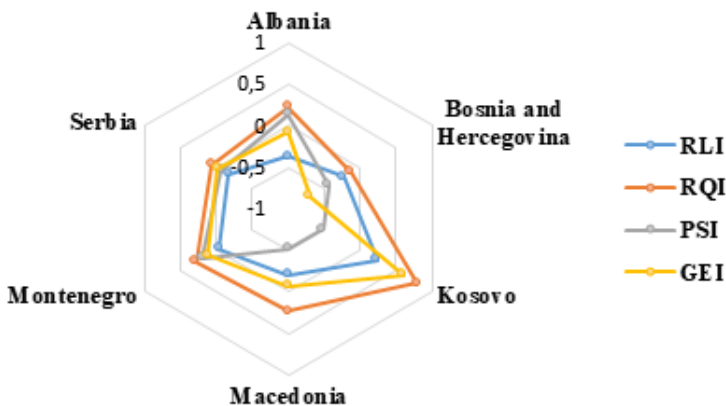
*Table 4. Environmental pollution indicators by Western Balkan countries*

Country	CO2C	CO2	PM 2.5	EUPC
Albania	1.59	4611.86	20.08	1.24
Bosnia and Hercegovina	6.36	21585.86	30.29	1.82
Kosovo	4.71	7563.86	30.99	1.46
Macedonia	3.95	8075.14	33.35	1.18
Montenegro	4.07	2513.64	22.72	1.21
Serbia	5.97	47448.14	49.69	1.92
<b>Western Balkans average</b>	<b>4.44</b>	<b>15299.75</b>	<b>31.19</b>	<b>1.47</b>

NOTE Data presented as average for the period 2010-2023

The radar chart (figure 1) represents the indicators of institutional quality for the Western Balkan countries. From the visual analysis, it is observed that the countries show large differences in their performance in each indicator. Serbia and Montenegro show high results in some indicators such as RLI and GEI, while Kosovo has significantly lower values, especially for PSI.

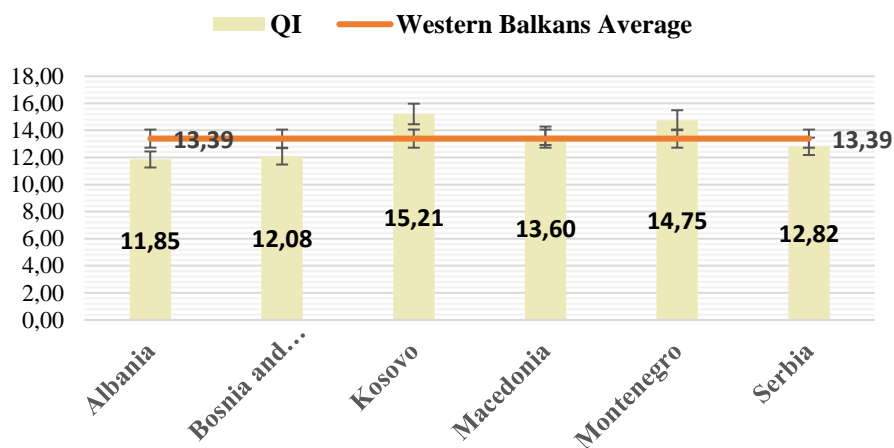
Meanwhile, Albania and Bosnia and Herzegovina show moderate performance in most indicators, but with some shortcomings in PSI and GEI. Macedonia seems to have more balanced results, although it does not reach the highest levels in any specific indicator. This chart illustrates the institutional challenges faced by these countries and underlines the importance of reforms to improve the quality of institutions, especially in areas where the assessments are lower.



**Figure 1.** Institutional quality indicators

Figure 2 presents a comparison of institutional quality (IQ) across the Western Balkan countries, comparing each country to the regional average of 13.39. Kosovo and Montenegro stand out for having values above the regional average, with Kosovo leading with 15.21, while Montenegro follows with 14.75. This indicates a better performance in institutional quality compared to other countries in the region.

Albania (11.85) and Bosnia and Herzegovina (12.08) have values lower than the average, reflecting greater challenges in strengthening their institutions. Serbia (12.82) and Macedonia (13.60) are closer to the average, with Macedonia just above the regional threshold. This shows that there is partial progress, but there remains room for improvements in the quality of governance and institutional arrangements. Although some countries such as Kosovo and Montenegro are performing well, most Western Balkan countries still face significant challenges in achieving higher standards of institutional quality.



**Figure 2.** Comparison of institutional quality in the Western Balkan countries

Table 5 presents the summary results of the three econometric models, where all three models were run with the random effects technique based on the Hausman test (M1,  $p=0.4244$ , M2,  $p=0.5521$  and M3,  $p=0.7821$ ). The three models are statistically significant ( $\text{Prob} > F = 0.000$ ), so the models are statistically significant. In none of the models is the problem of heteroskedasticity presented ( $\text{Hetttest} > 0.05$ ), while the problem of multicollinearity is not presented ( $\text{VIF} = 4.02$ ).

Table 5. Summary results of the three econometric models

Variables	CO2_log	EUPC	PM25
TRA	0.361	-0.481*	0.261**
	(0.81)	(-2.07)	(3.89)
PSI	0.0766	0.085	15.28
	(0.31)	(0.64)	(0.9)
RQI	-0.0822*	-0.0415*	0.944
	(-2.25)	(-2.12)	(0.39)
CC	-0.00136	-0.0156	0.0627
	(-0.04)	(-0.87)	(0.03)
REC	-0.461***	-0.78	-0.319**
	(-5.61)	(-0.15)	(-4.57)
QI	-0.344**	0.139*	-2.395***
	(-3.05)	(2.24)	(-3.32)
EUPC	1.064***		1.624
	(5.86)		(0.11)
RLI	-1.849*	-0.304	-23.53
	(-2.33)	(-0.69)	(-0.41)
GEI	-0.286**	-0.0545	11.29
	(-2.31)	(-0.46)	(0.74)
CT	-0.343***	-0.0397**	-0.888***
	(-3.05)	(-2.08)	(-5.19)
PM25	0.199	0.217	
	(1.14)	(0.23)	
CO2_log		0.303***	5.917
		(5.86)	(1.38)
_cons	13.51***	-1.991	12.25
	(11.35)	(-1.92)	(0.15)
N	84	84	84
R <sup>2</sup>	0.7692	0.8470	0.8283
F	143.41	121.42	98.42
Prob > F	0.000	0.000	0.000
VIF	4.02	4.02	4.02
Hetest	0.0999	0.3204	0.7143
Hausman Test	0.4244	0.5521	0.7821

NOTE t statistics in parentheses, \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

In the first model, where CO2\_log is the dependent variable, renewable energy (REC) has a negative and significant impact (B=-0.461, p<0.001), suggesting that increasing the use of renewable sources significantly reduces CO2 emissions. Also, the quality of institutions (QI) has

a negative and significant impact ( $B=-0.344$ ,  $p<0.01$ ), indicating that improving institutions reduces emissions. The carbon tax (CT) also has a negative and highly significant impact ( $B=-0.343$ ,  $p<0.001$ ), highlighting the importance of fiscal policies in reducing pollution.

In the second model, where EUPC is the dependent variable, trade (TRA) has a negative and significant impact ( $B=-0.481$ ,  $p<0.05$ ), indicating that increasing trade is associated with decreasing per capita energy consumption. Regulatory quality (RQI) has a negative impact ( $B=-0.0415$ ,  $p<0.05$ ), highlighting the importance of a strong regulatory environment for reducing energy consumption. Institutional quality (QI) has a positive and significant impact ( $B=0.139$ ,  $p<0.05$ ), indicating that strong institutions contribute to energy efficiency.

In the third model, where PM25 is the dependent variable, trade (TRA) has a positive and highly significant impact ( $B=0.261$ ,  $p<0.01$ ), suggesting that increased trade is associated with higher PM2.5 pollution. While renewable energy (REC) has a negative and significant impact ( $B=-0.319$ ,  $p<0.01$ ), indicating that increased use of renewable sources helps reduce air pollution. The carbon tax (CT) has a negative and highly significant impact ( $B=-0.888$ ,  $p<0.001$ ), indicating its role in reducing pollution.

Also, in the first and second models, the relationship between CO2 emissions (CO2\_log) and energy consumption per capita (EUPC) is significant and positive ( $B=1.064$ ,  $p<0.001$  and  $B=0.303$ ,  $p<0.001$ ), suggesting that increased emissions are associated with increased energy consumption.

Findings from the reviewed literature closely align with the results of this study, particularly regarding the role of renewable energy, institutional quality and fiscal policies in mitigating environmental pollution and improving energy efficiency. Amazhekaj et al. (2024) highlight the importance of institutional reforms in supporting the energy transition, particularly in reducing import dependency and promoting renewable energy, which corresponds to the significant negative impact of renewable energy (REC) on CO2 emissions ( $B=-0.461$ ,  $p<0.001$ ) observed in this study. This finding is in line with the literature, where renewable energy is shown to play a key role in both reducing emissions and boosting economic growth, as highlighted by the positive relationship between renewable energy consumption and GDP growth in the Western Balkans.

The importance of environmental taxes, as highlighted by Yurtsever and Uçar (2014), Liu et al. (2019), and Xu et al. (2023), is reflected in the significant and negative impact of carbon tax (CT) in this study ( $B=-0.343$ ,  $p<0.001$  for CO2 emissions and  $B=-0.888$ ,  $p<0.001$  for PM25). These results

highlight the effectiveness of fiscal policies in curbing environmental pollution, being in line with findings from the literature on the role of carbon taxes in reducing emissions and improving environmental quality. The significant negative relationship between institutional quality (IQ) and CO<sub>2</sub> emissions ( $B=-0.344$ ,  $p<0.01$ ) further supports the conclusion of Amazhekaj et al. (2024) that strong governance and institutional reforms are crucial in promoting energy efficiency and reducing pollution.

Findings also reveal some complexities, particularly with regard to the impact of trade (TRA) on energy consumption and pollution. While increased trade is associated with lower per capita energy consumption ( $B=-0.481$ ,  $p<0.05$ ), it is also associated with higher PM<sub>2.5</sub> pollution ( $B=0.261$ ,  $p<0.01$ ). This suggests that the economic benefits of trade may come with environmental costs, a nuance not fully explored in the literature but worthy of further investigation. The negative effect of regulatory quality (RQI) on energy consumption ( $B=-0.0415$ ,  $p<0.05$ ) highlights the importance of a strong regulatory environment, which is consistent with the broader literature on the role of regulations in promoting sustainable energy use.

Hypothesis H<sub>1</sub>, which proposes that the effectiveness of environmental policies in the Western Balkans is influenced by the strength of the institutional framework and political stability, was tested by analyzing the variables of quality of institutions (QI) and political stability (PSI) in econometric models. The results showed that the quality of institutions has a negative and significant impact on CO<sub>2</sub> emissions ( $B=-0.344$ ,  $p<0.01$ ), suggesting that improving institutions reduces environmental pollution. However, political stability (PSI) did not show a statistically significant impact on any of the environmental indicators, including CO<sub>2</sub> and PM<sub>2.5</sub>, suggesting that political stability alone, without improving institutional quality, is not sufficient to significantly affect the effectiveness of environmental policies. These findings partially support the hypothesis, underlining the importance of strengthening institutions for increasing the effectiveness of environmental policies, while political stability can serve as a supporting factor, but not a self-sufficient one.

## 5. Conclusions

The study analyses the impact of various economic, institutional and environmental factors on CO<sub>2</sub> emissions, per capita energy consumption and PM<sub>2.5</sub> pollution in the Western Balkan countries. The results show that improving the quality of institutions and increasing the use of renewable

sources play an important role in improving environmental and energy indicators in the region.

The use of renewable energy (REC) has been identified as a key factor in reducing CO<sub>2</sub> emissions and PM<sub>2.5</sub> pollution. This shows the importance of switching to more sustainable energy sources to improve air quality and reduce global pollution. These results support the need for policies that promote the use of renewable energy as part of national and regional strategies for environmental protection.

Fiscal policies, such as carbon taxes (CT), have shown a strong negative and very significant impact on reducing emissions and PM<sub>2.5</sub> pollution. This shows that well-designed fiscal measures can play an important role in improving environmental sustainability by creating economic incentives to reduce pollution.

Institutional quality (QI) has been shown to have a significant impact on reducing CO<sub>2</sub> emissions and improving energy efficiency. These results highlight that improving transparency, efficiency and the rule of law contribute to creating a more sustainable and environmentally responsible environment. Trade (TRA) appears as a complex factor. While it has a negative impact on per capita energy consumption, it is also positively associated with PM<sub>2.5</sub> pollution. Thus, economic development through trade contributes to increased pollution, highlighting the need for control mechanisms and environmental regulations as trade expands.

Linking sustainable environmental policies and improving institutions is key to reducing pollution and improving environmental and energy performance. To address the environmental challenges of the Western Balkans, countries need to engage in stronger renewable energy policies, implement carbon taxes, and improve institutional governance. This will ensure a more integrated approach to sustainable development and a cleaner environment for the region.

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