DOI: 10.28934/ea.23.56.1.pp43-56

ORIGINAL SCIENTIFIC PAPER

Exploring the Economy – Environment Interactions in the Western Balkans: A Panel Data Analysis

Petar Mitić[1]* | **Aleksandra Fedajev[2]** | **Milena Kojić[1]**

[1] Institute of Economic Sciences, Department for Environmental Economics, Belgrade, Serbia
[2] The University of Belgrade, Technical Faculty in Bor, Bor, Serbia

ABSTRACT

In order to balance economic growth with environmental preservation, the implementation of sustainable policies is necessary. As such, it is imperative to have a comprehensive understanding of the intricate relationship between the economy and the environment. This study examines the relationship between CO_2 emissions and GDP per capita in five WB countries during 1960-2018, using a methodological framework that includes panel unit root testing, cointegration testing, and a Vector Error Correction Model. The study provides robust evidence of a long-term cointegration between CO_2 emissions and GDP per capita. Furthermore, the study also reveals a short-run bidirectional causal relationship between CO_2 emissions and GDP per capita. In the long run, no statistically significant causality exists from GDP per capita to CO_2 emissions, but it is statistically significant from CO_2 emissions to GDP per capita. These findings offer valuable insights for policymakers to develop comprehensive policies that promote economic growth and environmental sustainability, such as investing in clean energy, implementing stronger environmental regulations, and encouraging environmentally sound management practices.

Keywords: economic growth, CO_2 emissions, WBs, panel causality, sustainability

JEL Classification: C33, O13, Q56

INTRODUCTION

Threats of global warming have steadily grown in recent years. The European Union (EU) has emphasized the need for climate change mitigation measures and has set ambitious targets for reducing Greenhouse Gas (GHG) emissions (Skjærseth, 2021; Dolge & Blumberga, 2021). Including the Western Balkan (WB) countries in the European Green Deal strategy and guiding the area toward 2030 and 2050 climate neutrality goals with EU money and support could expedite the region's transformation. As a strategy that the EU and the WB will jointly implement, the Green Agenda can increase chances for successfully implementing climate-neutral policies and create more economically feasible scenarios for fast reductions in GHG emissions only in the short term. For long-term success, it is critical that neighboring countries also take significant environmental action. Only in this way will the Green Deal agenda be entirely successful (Ćetković et al., 2021).

As "going green" becomes inevitable for both individuals and organizations (Tongsoongnern & Lee, 2022), transitioning to a "green" growth path remains challenging, particularly in the short

---

* Corresponding author, e-mail: petar.mitic@ien.bg.ac.rs

term, due to the reluctance of WBs to abandon traditional "brown" sectors, skills, employment, market infrastructure, and established value chains. Accelerated structural reforms must be carried out alongside a rational economic policy to attain sustainable economic growth (Marjanović et al., 2021). Although the carbon intensity of economic growth has decreased in recent years, it is still many times higher than in the EU (World Bank, 2022). In 2018, the WB produced about 100 Mt of CO_2 emissions from combustion and fossil fuel operations, accounting for nearly 3% of EU CO_2 emissions that year. Although there were many changes during those years, and energy consumption altered due to political changes in the WB nations, this value is similar to 1990. CO_2 emissions in the region were 8.7% lower in 2018 than in 1990 (Banja et al., 2020).

However, the actions aimed at reducing pollution affect economic growth rates, which are already very low or even negative during the past few years (Matić et al., 2022). After a severe economic downturn caused by the COVID-19 pandemic (Kisin et al., 2021), the WB countries are reconsidering their long-term growth and development strategies. They are at the crossroads of their future development path where they should decide if their development should be based on a "brown" recovery (which means employing existing manufacturing methods and benefiting from low costs of coal and labor and foreign direct investments inflow) or fundamentally change their economy to a "green" growth model. Although the traditional "brown" industries require minor adjustments to crisis conditions, they are accompanied by high economic and environmental costs. On the other hand, "green" growth is not easy to achieve, and its benefits are not so apparent in the short term, especially as fiscal space has narrowed and the higher debt burden imposed by the crisis has limited the actions and funds available to governments when it comes to significant investments. Nevertheless, continuing with the traditional "brown" growth will make long-term economic growth and development unsustainable (World Bank, 2021).

Given the doubts about future development strategies, there is significant relevance to researching the interdependencies between environmental degradation and economic growth for the WB countries. Such research can assist the WBs in achieving long-term economic recovery while also satisfying environmental goals, thereby promoting economic growth and development. In particular, investigating these interdependencies in the WB region is significant as it has not been extensively studied in previous research. As these goals are typically viewed as opposing in WB countries, understanding the link between them may also have relevance for the EU when these countries join the Union.

The research examines how CO_2 emissions and GDP per capita are related in five countries of the World Bank. The study uses panel data analysis, which involves conducting tests for cross-sectional dependence, unit root, cointegration, and Granger causality and constructing a vector error correction model. This approach allows for investigating the link between economic growth and environmental degradation.

The paper is organized as follows. Section 2 presents a literature review of the relationships between economic and environmental indicators and their implications for developing countries, including the critical economic and environmental prerequisites for the balanced growth of WBs. Section 3 describes the methodology for analyzing the relationship between economic growth and environmental degradation using panel data. Section 4 presents the main research results. Section 5 discusses obtained results in the WBs, including policy implications of derived findings. Finally, Section 6 concludes the paper while contributing to the ongoing debate about the relationship between economic growth and environmental quality in the WB region.

LITERATURE REVIEW

It is crucial to understand the relationship between economic growth and environmental deterioration to ensure the long-term sustainability of economic development. Although economic growth can improve living standards and expand access to resources, it frequently harms the environment, leading to deforestation, air and water pollution, and climate change. Researchers from many fields, including economics, environmental science, and ecology, have thoroughly examined this relationship using statistical analyses, case studies, and modeling approaches. Their findings have highlighted the complexity of this relationship and helped shape policies and strategies for fostering sustainable economic growth and reducing environmental damage. This literature review section provides a brief overview of the extensive scientific research on this topic and the insights gained from it.

The Environmental Kuznets Curve (EKC) is possibly the most prominent theory when analyzing economic growth and environmental degradation at country, regional, and group of countries levels. EKC theory suggests that environmental degradation initially increases as a country experiences economic growth and industrialization but eventually declines once a certain level of economic development is reached. This theory assumes that as a country gains additional wealth, it has the resources to invest in environmental protection measures and shift towards cleaner technologies.

The validity of the EKC hypothesis has been extensively examined in various studies using panel data and time series methods. Panel data studies conducted by Apergis & Ozturk (2015), Ummalla & Goyari (2020), and Pata et al. (2022) support the presence of the EKC, while time series studies for individual countries by Sarkodie & Ozturk (2020), Suki et al. (2020), Jiang et al. (2021), Jahanger et al. (2022), and Voumik et al. (2022) also confirm its existence. However, some research suggests that environmental degradation continues to persist even at higher levels of economic growth, as shown in panel studies by Özokcu & Özdemir (2017) and Hussain & Dogan (2021) and individual countries studies by Ozturk & Acaravci (2010), Yilanci & Pata (2020), and Villanthenkodath et al. (2021). Additionally, some studies provide conflicting evidence depending on the variable selection, such as those conducted by Aung et al. (2017), Mrabet & Alsamara (2017), and Ansari (2022). Overall, the EKC remains contested, and further research is valuable to clarify its existence and validity.

Achieving both goals – increasing economic growth and pollution mitigation is especially challenging for developing and transition countries like WBs. Adedoyin et al. (2020) analyzed the relationship between energy production and CO_2 emissions in three groups of countries from 1992 to 2014: Central and Eastern Europe (CEE), the Commonwealth of Independent States (CIS), and New Member States (NMS). According to the empirical findings, a 1% increase in renewable energy production causes CO2 emissions to rise by 0.04% and 0.02% in CIS and CEE countries but fall by 0.02% in NMS countries. Mitić et al. (2023) researched the situation in eight South-Eastern European countries and found a short-run bidirectional causality between CO_2 emissions and employment and between available energy and employment. The long-run causal relationship results suggest that CO2 emissions, GDP, and employment could significantly affect the system's adjustment process as it departs from long-run equilibrium. Mitić et al. (2017) used cointegration analysis to investigate a link between GDP and CO_2 emissions in transition economies. According to the recommendations given in this study, transition economies should follow global initiatives and adopt new processes and tools to control and restrict CO_2 emissions if they want to minimize CO_2 emissions while maintaining sufficient GDP growth. Furthermore, Arndt et al. (2017) emphasized that including developing countries in any successful global mitigation program is justified, given the level of existing emissions from developing countries and their high growth rates.

The WB countries are still establishing and enhancing the appropriate legislative framework and strategies for climate change mitigation. Furthermore, the implementation of these frameworks and strategies is still insufficient. The adoption strategy must involve transitioning to power plants using cleaner energy sources and identifying concrete economic policy goals and government support measures (Knez et al., 2022). It should be noted that the application of the EU acquis on environment and climate in WB countries varies. It ranges from the basic stages of implementation to more advanced ones (Banja et al., 2020).

Considering the significant challenges to long-term development prospects, it will be necessary for WB economies to undertake fundamental reforms and boost economic transformation. The financial sector can help to ease this transformation. Unfortunately, green finance has fallen short of the needed size and scope internationally and notably in the WBs (World Bank, 2022). Besides financial sector weaknesses, the institutional environment is still not sufficiently developed to enable a smooth transition to green growth. The WBs have been through a difficult economic and political upheaval during the previous 30 years. Following the chaotic and conflict-ridden 1990s, which had many adverse political and economic effects, the WBs region had an economic recovery at the beginning of the new century. Economic growth trends and transition processes in economies of this region have resulted in a need for additional energy, requiring upgrades to the entire energy supply system. One of the fundamental characteristics of all the countries in the region is their reliance on solid fossil fuels, primarily coal, as an energy source while simultaneously being heavily reliant on oil, coal, and natural gas imports (Dunjic et al., 2016). The energy sector, particularly coal, produces the most pollution. On the other side, there is a scarcity of mechanisms for monitoring, reporting, and verifying greenhouse gas emissions (Berishaj, 2021).

Recent decades' political and economic changes significantly impacted the energy supply of individual WB countries. Except for Albania, all countries were part of a single energy system before gaining independence. Most WB countries inherited their energy infrastructure (for example, for oil, gas, and electricity) from the Socialist Federal Republic of Yugoslavia (SFRY), where most of the production units were outdated, requiring rebuilding and efficiency improvements (Lalic, 2011). Consequently, one of the key characteristics of the WBs' energy systems is their low energy efficiency, primarily reflected in power distribution energy losses (Sanfey et al., 2016). The inadequately maintained and outdated energy infrastructure resulted in significantly greater energy intensity than the EU average.

The primary underlying reasons for excessive air pollution in the region are capacity limits and governance challenges in implementing comprehensive, cross-sectoral air quality control initiatives. Common issues include unsuitable regulations, insufficient enforcement of laws, and technological capacity shortages, such as incomplete emissions inventories and a lack of adequate air quality monitoring. Furthermore, a country's low institutional capability, mainly vertical and horizontal institutional coordination, poses a challenge to responding adequately when air pollution affects many sectors (Kikoni & Schiffbauer, 2020). Typically, air pollutants generated mainly through human activities such as industry (including energy production), domestic heating, and transportation exceed the country's standards. Meanwhile, the WB countries' primary sources of GHG are energy and transportation (Banja et al., 2020).

The mitigation of air pollution resulting from increased economic growth, especially industrial activities, will not be possible without switching to renewable energy sources (RES) in producing energy. Countries in the WBs have considerable renewable energy potential. In their long-term policies, many of them have set ambitious sectorial RES targets. Nevertheless, there is a huge disparity between these goals and the actual outcomes. Although renewables provide numerous benefits acknowledged globally, the penetration of RES into global and local energy markets remains limited (Đurašković et al., 2021).

Due to numerous economic, environmental, political, and institutional challenges faced by WBs, it is necessary to intensify research in this area. It is crucial to consider the similarities of WBs but also the specificities of each country within the region to respond adequately to inherited problems and prospects. In this regard, this research is one of the necessary steps in this direction and should motivate more authors to focus their research on this region.

DATA AND METHODOLOGY

The study uses GDP and CO_2 emissions data for five WB countries: Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia. The data span a period from 1960 to 2018. The real GDP per capita data was obtained from the Maddison Project Database 2020 and used as a measure of economic growth (Jutta & van Zanden, 2020). The data for CO_2 emissions per capita were obtained from the Global Carbon Atlas, a widely recognized source for CO_2 emissions data (Global Carbon Atlas, 2022; Friedlingstein et al., 2022; Andrew & Peters, 2021; UN, 2019). It is important to note that the data for the time frame between 1960 and 1995 are approximations for all countries except Albania. This is because, during this period, all countries except Albania were a part of the Socialist Federative Republic of Yugoslavia (SFRY), and reliable data for each country is unavailable. Therefore, the data estimates were done ex-post using available information. Both data sets were collected for the same countries and periods, allowing for an analysis of the relationship between economic growth and environmental quality in the WBs.

The econometric analysis in this research is based on the methodology framework presented in Figure 1.

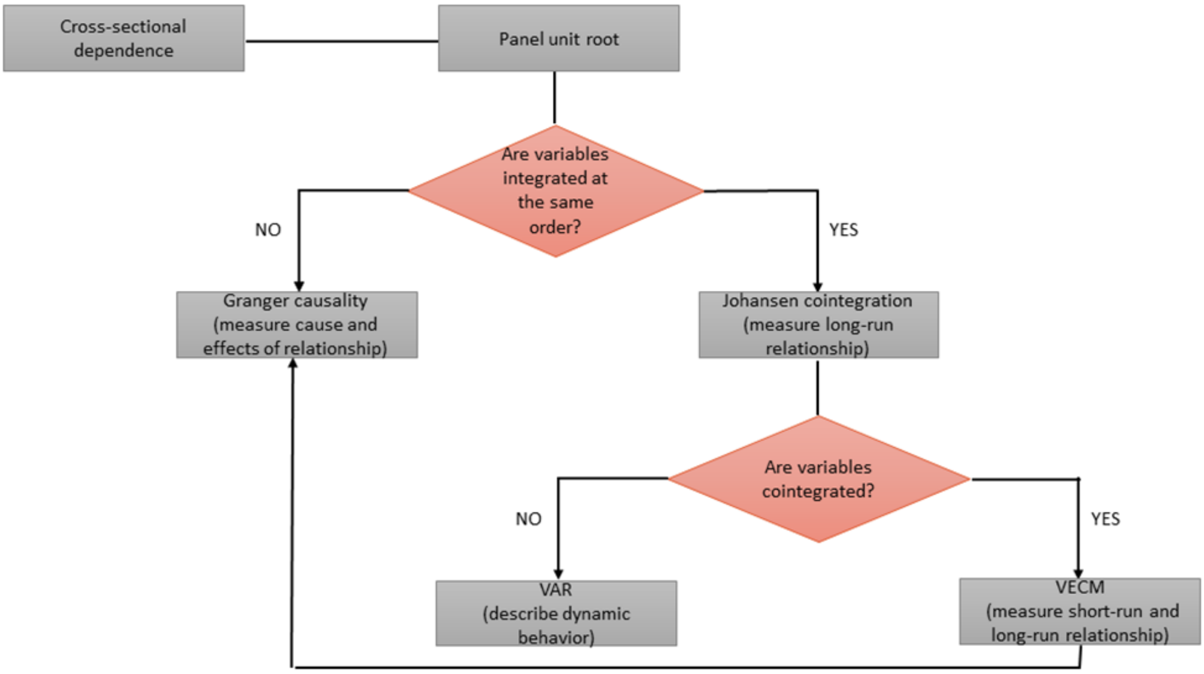

Figure 1. Methodology framework

Source: Authors.

The first methodology framework step is to conduct cross-sectional dependence tests. These tests are vital diagnostics before estimating any panel data models. The presence or lack of cross-sectional dependency dictates the next methodological step. If cross-sectional dependence is detected in the data, additional analysis processes must be conducted to account for it. Only a few cross-sectional reliance tests are available to identify the cross-sectional dependency issue (see Table 1 for a summary).

Table 1. Residual cross-section dependence test

Test	**Test**	**Application**
Breusch and Pagan (1980)	LM test	Panels with a small number of cross-section units.
Pesaran (2004)	scaled LM	Panels with a large number of cross-sectional units and large time dimensions.
Pesaran (2004)	CD test	Panels with a small number of cross-sectional units and small-time dimensions.
Baltagi et al. (2012)	bias-corrected scaled LM test	Panels with a large number of cross-sections and small-time dimensions.

Source: Authors.

If the panel dataset consists of a small number of cross-section units, then the Breusch and Pagan (1980) LM test is the most reliable choice. If the panel dataset consists of many cross-section units, then the better choice is the Pesaran (2004) scaled LM test, a standardized version of the LM test. Pesaran's (2004) CD test is the most appropriate if the panel dataset consists of small cross-sections and time dimensions. Finally, for panel datasets with panels with large cross-sections and small-time dimensions, the best choice is bias correction for the scaled LM test proposed by Baltagi et al. (2012). The null hypothesis in these tests is "There is no cross-sectional dependence in the data." We used all four tests to look for any cross-sectional dependence between the time series in the research to confirm the accuracy of the findings.

Since the results demonstrated the absence of cross-sectional dependence (see Results section), panel unit root tests of the first generation have been applied. The order of cointegration is determined through five-panel unit root tests: Levin, Lin & Chu (Levin et al., 2002), Breitung (Breitung, 2001), Im, Pesaran, and Shin (Im et al., 2003), Fisher-ADF (Maddala & Wu, 1999) and Fisher-PP (Choi, 2001) tests. The existence of a unit root is the null hypothesis for each of the five tests, as opposed to the alternative hypothesis that there is not one. Each test is applied to logarithm transformations of the time series at the level and then at first difference.

Once the panel unit root tests have been applied, the next methodological step is to apply the Johansen-Fisher panel cointegration maximum likelihood-based test (Johansen, 1988; Johansen, 1995). The proof that the time series are all not stationary at level is sufficient for examining the cointegration and the long-run relationship between the variables. The Johansen-Fisher panel cointegration test is based on Johansen's methodology and maximum eigenvalue. The initial point is a vector autoregression (VAR) of the order of p

$$y_t = \mu + \sum_{i=1}^{p} A_i y_{i-1} + \epsilon_t, \tag{1}$$

where y_t is an $n \times 1$ vector of variables integrated of order one $I(1)$ variables, A is an autoregressive matrix, μ is intercept and ϵ_t is an $n \times 1$ vector of innovations. The model can be rewritten as

$$\Delta y_t = \mu + \Pi \mathrm{Y}_{\mathrm{t-1}} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{i-1} + \epsilon_t\,, \tag{2}$$

where $\Pi = \sum_{i=1}^{p} A_i - \mathrm{I}$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$ for $i = 1, \dots, p$.

If the matrix Π does not have full rank but rather reduced $r < n$, then there exist two $n \times r$ matrices α and β with rank r such that $\Pi = \alpha\beta'$, where the elements of α are the analogous adjustment of coefficient in the VECM and β is the matrix of parameters of the cointegrating vector. We apply the Maximum Eigenvalue test, which can be expressed as

$$\lambda_{max} = Nlog(1 - \lambda_{r+1}) \tag{3}$$

where N is the length of the time series and λ denotes characteristic roots obtained from the projected matrix. The null hypothesis is that there are r cointegration ($r = 0$) vectors, and the alternative hypothesis is that there are $r + 1$ cointegration vectors. That is null hypothesis is that there is no cointegration among variables. The above test statistic does not follow the chi-square distribution and is based on pure unit-root assumption. If there is cointegration among variables, it means a long-run interrelationship exists among them.

The following methodology step evaluates the short-run relationship of cointegrated series by estimating Vector Error Correction Model (VECM). The existence of cointegration suggests a causality relation among variables, at least in one direction. We estimate the VECM and use Granger Causality. Dynamic panel causality test established on VECM is developed in the equations

$$\Delta CO_{2,t} = \alpha^c + \sum_{i=1}^{m} \gamma_i^c \, \Delta CO_{2,t-1} + \sum_{s=1}^{q} \delta_s^c \, \Delta GDP_{i,t-s} + \lambda^c ECT_{t-1}^c + u_i \tag{4}$$

$$\Delta GDP_t = \alpha^g + \sum_{i=1}^{m} \gamma_i^g \, \Delta GDP_{2,t-i} + \sum_{s=1}^{q} \delta_s^g \, \Delta CO_{2,t-s} + \lambda^g ECT_{t-1}^g + v_i, \tag{5}$$

where $ECT_{t-1}^{c,g}$ denotes lagged residuals estimated from the long-run cointegration, γ_i^c and δ_s^g denote short-run adjustment coefficients, and u_i and v_i denote uncorrelated zero mean disturbance terms. The Akaike or the Schwarz Information determines the optimal lag lengths m and q. Firstly, the existence of long-run causality can be reviewed by checking the significance of the speed of adjustment of the coefficients of $ECT_{t-1}^{c,g}$ that is $\lambda^{c,g}$. The coefficients indicate the speed at which adjustments to deviations from the long-term equilibrium occur in response to alterations in individual variables. The statistical significance of coefficients $\lambda^{c,g}$, determines the long-run relationship in the cointegrating process, and movements along this path can be deemed permanent. Secondly, the statistical significance of the coefficients γ_i^c and δ_s^g can be interpreted as a short-run causality because the dependent variable responds only to short-term shocks to the stochastic environment.

RESULTS AND DISCUSSION

Results

The Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD tests are principally conducted to detect any cross-sectional dependence among the time series. Based on the results presented in Table 2, the null hypothesis of no cross-sectional dependence (correlation) in weighted residuals is accepted, suggesting an absence of correlation or cross-sectional dependency among the time series.

Table 2. Residual cross-section dependence test

Test	Statistics
Breusch-Pagan LM	2.013904
Pesaran scaled LM	-1.785745
Bias-corrected scaled LM	-1.828849
Pesaran CD	-0.395904

*Source: Authors' calculation. Note: Statistical significance levels are indicated as follows: *** represents significance at p < 0.001; ** represents significance between p = 0.001 and p = 0.01; * represents significance between p = 0.01 and p = 0.05. Cross-section effects were removed during computation.*

The first generation of tests assumes that cross-sectional units are independent of each other, while the second generation tests relaxes this assumption and permits cross-sectional dependence.

Before conducting cointegration testing, it is crucial to establish the order of cointegration using five panel unit root tests: Levin, Lin & Chu, Breitung, Im, Pesaran, and Shin, as well as ADF-Fisher and PP-Fisher tests. In all five tests, the null hypothesis is that a unit root exists, with the alternative hypothesis being the absence of a unit root. The outcomes of these tests are presented in Table 3.

Table 3. Panel unit root test results

Variable	**Levin, Lin & Chu t***	
	Level	First Difference
CO_2	-0.67385	-21.8346***
GDP	-0.25069	-6.65684***
	Breitung t-stat	
	Level	First Difference
CO_2	1.05322	-15.7657***
GDP	-1.48945	-8.51767***
	Im, Pesaran and Shin W-stat	
	Level	First Difference
CO_2	0.47319	-18.9006***
GDP	0.23179	-7.11565***
	ADF - Fisher Chi-square	
	Level	First Difference
CO_2	6.19320	187.563***
GDP	8.76358	63.2753***
	PP - Fisher Chi-square	
	Level	First Difference
CO_2	7.16849	189.432***
GDP	4.52145	71.9744***

*Source: Author's calculation. Note: Statistical significance levels are indicated using the following notation: *** denotes significance at p < 0.001, ** denotes significance between p = 0.001 and p = 0.01, and * denotes significance between p = 0.01 and p = 0.05. The unit root tests employed Schwarz automatic selection to determine the lag length. Fisher tests used an asymptotic Chi-square distribution for computing probabilities, while all other tests assume asymptotic normality.*

The results from the five tests demonstrate that all variables are non-stationary at level but stationary when converted to first differences. At the 0.01 significance level, we fail to reject the null hypothesis of a unit root at level, but we can reject the null hypothesis of a unit root for the first difference. As such, the variables are integrated of order 1 – I(1). All tests indicate non-stationarity at level and stationarity at the first difference, prompting us to proceed with cointegration testing.

Therefore, Table 4 displays the outcomes of the Johansen Fisher Panel Cointegration test, which reveals that there is at least one cointegrated equation, signifying that the variables are cointegrated in the long-run. According to Pao & Tsai (2011), confirming cointegration eliminates the possibility of spurious relationships. These results suggest that there is Granger causality, at least in one direction.

Table 4. Johansen Fisher panel cointegration test results

Null hypothesis: Variables are not cointegrated		
Hypothesized No. of CE(s)	**Trace**	**Maximum eigenvalue**
r = 0	22.02*	20.03*
r ≤ 1	14.05	14.05

*Source: Author's calculation. Note: Statistical significance levels are indicated using the following notation: *** denotes significance at p < 0.001, ** denotes significance between p = 0.001 and p = 0.01, and * denotes significance between p = 0.01 and p = 0.05. The symbol r represents the number of cointegrating equations. The interval for lags is set to 1 1 (in first differences). The probabilities are computed using an asymptotic Chi-square distribution.*

Given that the Johansen Fisher cointegration tests confirm the existence of a long-run relationship between the variables in our model, the vector error correction approach is a viable method for estimating the cointegrating coefficients.

Table 5. Panel causality analysis results

Short-run Granger causality			**Error correction**	
	ΔCO_2	ΔGDP	ECT (-1)	Coeff.
ΔCO_2	-	54.25702***	-1.250434	-0.013515
ΔGDP	61.16536***	-	-3.051348**	-0.016419

*Source: Authors' calculation. Note: Statistical significance levels are indicated using the following notation: *** denotes significance at p < 0.001, ** denotes significance between p = 0.001 and p = 0.01, and * denotes significance between p = 0.01 and p = 0.05. Δ denotes the first difference operator, while ECT (-1) represents the error correction term lagged one year.*

The results of a Granger causality test and a VECM for the relationship between CO_2 emissions (ΔCO_2) and GDP per capita (ΔGDP) are presented in Table 5. The variables are expressed as first differences (Δ), implying that the analysis is performed on the changes in the variables over time.

The results of the short-run Granger causality test reveal a short-run causal relationship between the changes in CO_2 emissions and GDP per capita, as the significance level of the test ($p < 0.001$) indicates statistical significance. This implies that over the short run, changes in CO_2 emissions significantly impact changes in GDP per capita and vice versa, establishing a short-run bidirectional panel causality between CO_2 emissions and GDP per capita.

The findings, however, imply no statistically significant long-term causality from GDP per capita to CO_2 emissions. The lack of a long-term causality from GDP to CO_2 implies there is a lack of evidence that aberrations from this relationship are corrected over time, as the Error Correction Term (ECT) for ΔCO_2 (-1.250434) is statistically non-significant. Nevertheless, the non-significant ECT for ΔCO_2 emissions does not necessarily suggest no long-run relationship between the two variables; therefore, this conclusion should be cautiously approached. Other factors, such as the sample size, the presence of omitted variables, or measurement error, could also affect the significance of the ECT. This claim is further supported by the fact that, as mentioned above, the results of the short-run Granger causality test still suggest a causal relationship between ΔCO_2 and ΔGDP over the short run.

This assertion is further strengthened by the statistically significant ECT(-1) for ΔGDP, which points to a long-term causality from CO_2 emissions to GDP per capita. A decrease in CO_2 emissions is associated with a rise in GDP. The long-run equilibrium between the two variables is represented by the ECT (-3.051348**), with the negative and statistically significant ECT showing a negative adjustment mechanism to correct deviations from the long-run relationship. Therefore, it might be concluded that the findings imply a long-term relationship between CO_2 emissions and GDP with a negative adjustment mechanism to remedy aberrations from this relationship. The scale of the ECT can be used to estimate the speed of adjustment.

Discussion and Policy Implications

Long-term economic disruption may result from the detrimental effects of CO_2 emissions on the environment (such as climate change and air pollution). For instance, extreme weather events, like hurricanes, floods, and droughts, brought on by climate change can harm infrastructure, sabotage supply chains, and lower agricultural productivity. Air pollution can also have health impacts on individuals, leading to more considerable healthcare costs and diminished workforce productivity.

The findings of this paper have significant policy ramifications for the WB countries. Initially, the cointegration results show that CO_2 emissions and GDP per capita have a long-term relationship, suggesting that a long-run relationship exists between the variables. This finding is significant because it emphasizes the link between environmental sustainability and economic growth in the WBs. Furthermore, the Granger causality test results and the VECM suggest a short-run bidirectional causality between CO_2 emissions and GDP per capita. The importance of simultaneously addressing economic growth and environmental sustainability in WB countries' policies and plans is highlighted by this finding.

Furthermore, the statistically significant error correction term for ΔGDP suggests that a long-term causal relationship exists and runs from CO_2 emissions GDP per capita, with a negative adjustment mechanism to correct deviations from the long-run relationship. This suggests that a decline in CO_2 emissions results in a rise in GDP per capita, underscoring that policies and actions to cut CO_2 emissions, such as improving energy efficiency, encouraging the use of green energy sources, and implementing carbon taxes, can have positive spillover effects on the economy. As shown in a recent study (Đurašković et al., 2021), investing in renewable energy can have positive impacts on both employment and innovation. Furthermore, improving energy efficiency can decrease production costs and increase competitiveness. These benefits can be achieved by developing and implementing energy-efficient technologies, such as smart grids and energy-efficient buildings, as well as using renewable energy sources like solar and wind power. By adopting such measures, economies in the WB region can reduce their dependence on fossil fuels and mitigate the potential impact of global energy market fluctuations.

In order to encourage businesses to cut their CO_2 emissions and embrace environmentally friendly practices, policymakers in the WBs ought to consider the complex interplay between economic growth and environmental sustainability to formulate policies that balance both objectives. Investing in clean energy and green technologies through green finance (World Bank, 2022), enacting stronger environmental regulations and taxes, following global initiatives in this area (Mitić et al., 2017; Arndt et al., 2017), and encouraging environmentally sound management techniques can help reduce pollution and protect natural resources while stimulating economic growth. By adopting a comprehensive approach to policy-making, WB countries can achieve sustainable development and contribute to a greener future for the region and beyond.

CONCLUSION

The WBs have undergone significant economic and political transitions in recent decades, resulting in increased industrialization and urbanization with significant environmental impacts, leading to growing concerns about the region's environmental sustainability and its potential effects on economic growth. The Sofia Declaration on the Green Agenda for the WBs and other international policies have highlighted the importance of balancing economic and environmental sustainability in the region.

This paper's findings add to the research on the intricate link between economic growth and the environment in the WBs. The cointegration results suggest a long-term relationship between CO_2 emissions and GDP per capita, emphasizing the need to address economic growth and environmental sustainability in policies and plans. Furthermore, the VECM has identified a negative adjustment mechanism suggesting a rise in CO_2 emissions will cause a decline in GDP per capita, highlighting the need for sustainable economic growth to lower CO_2 emissions and protect the environment.

The short-term bidirectional causality between CO_2 emissions and GDP per capita further underscores the need for policymakers to adopt a comprehensive approach to policy-making. Investing in clean energy and green technologies, enacting stronger environmental regulations and taxes, and encouraging environmentally sound management techniques can help reduce pollution and protect natural resources while stimulating economic growth. Policymakers can use these findings to formulate policies that balance economic growth and environmental sustainability.

However, more research is needed to fully understand the complex relationship between economic growth and the environment in the WBs. Future studies can build on these findings to further inform policies and plans that promote sustainable development in the region. Additionally, it is important to consider other environmental, social, and economic variables, such as population growth, income inequality, and access to education and healthcare, to develop a comprehensive understanding of the challenges and opportunities for sustainable development in the region.

ACKNOWLEDGMENTS

This research has been financed by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia.

REFERENCES

Adedoyin, F., Abubakar, I., Bekun, F. V., & Sarkodie, S. A. (2020). Generation of energy and environmental-economic growth consequences: is there any difference across transition economies?. *Energy Reports*, *6*, 1418-1427. https://doi.org/10.1016/j.egyr.2020.05.026

Andrew, R. M., & Peters, G., P. (2021). The Global Carbon Project's fossil CO2 emissions dataset. Zenodo. https://doi.org/10.5281/zenodo.5569234

Ansari, M. A. (2022). Re-visiting the Environmental Kuznets curve for ASEAN: A comparison between ecological footprint and carbon dioxide emissions. *Renewable and Sustainable Energy Reviews*, *168*, 112867. https://doi.org/10.1016/j.rser.2022.112867

Apergis, N., & Ozturk, I. (2015). Testing Environmental Kuznets Curve hypothesis in Asian countries. *Ecological indicators*, *52*, 16-22. https://doi.org/10.1016/j.ecolind.2014.11.026

Arndt, C., Miller, M., Tarp, F., Zinaman, O., & Arent, D. (2017). *The Political Economy of Clean Energy Transitions*. Oxford University Press.

Aung, T. S., Saboori, B., & Rasoulinezhad, E. (2017). Economic growth and environmental pollution in Myanmar: an analysis of environmental Kuznets curve. *Environmental Science and Pollution Research*, *24*(25), 20487-20501. https://doi.org/10.1007/s11356-017-9567-3

Baltagi, B. H., Feng, Q., & Kao, C. (2012). A Lagrange Multiplier test for cross-sectional dependence in a fixed effects panel data model. *Journal of Econometrics*, *170*(1), 164–177. https://doi.org/10.1016/j.jeconom.2012.04.004

Banja, M., Đukanović, G., & Belis, C. (2020). Status of air pollutants and greenhouse gases in the WBs. *EUR 30113 EN, Publications Office of the European Union, Luxembourg,* ISBN 978-92-76-16861-4, doi:10.2760/557210, JRC118679.

Berishaj, V. (2021). WBs Greenhouse Gas Emission Reduction Targets 2030. *Climate Action Network Europe: Brussels, Belgium*.

Breitung, J. (2001). The local power of some unit root tests for panel data. In Non-stationary Panels, Panel Cointegration, and Dynamic Panels (Advances in Econometrics, Vol. 15), ed. Baltagi, B.H., Fomby, T.B. and Carter Hill, R., 161-177. Emerald Group Publishing Limited, Bingley. https://doi.org/10.1016/S0731-9053(00)15006-6

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. *The Review of Economic Studies*, *47*(1), 239. https://doi.org/10.2307/2297111

Ćetković, J., Lakić, S., Živković, A., Žarković, M., & Vujadinović, R. (2021). Economic analysis of measures for GHG emission reduction. *Sustainability*, *13*(4), 1712. https://doi.org/10.3390/su13041712

Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance*, *20*(2), 249–272. https://doi.org/10.1016/s0261-5606(00)00048-6

Dolge, K., & Blumberga, D. (2021). Economic growth in contrast to GHG emission reduction measures in Green Deal context. *Ecological Indicators*, *130*, 108153. https://doi.org/10.1016/j.ecolind.2021.10815

Dunjic, S., Pezzutto, S., & Zubaryeva, A. (2016). Renewable energy development trends in the WBs. *Renewable and Sustainable Energy Reviews*, *65*, 1026–1032. https://doi.org/10.1016/j.rser.2016.05.051

Đurašković, J., Konatar, M., & Radović, M. (2021). Renewable energy in the WBs: Policies, developments and perspectives. *Energy Reports*, *7*, 481–490. https://doi.org/10.1016/j.egyr.2021.07.104

Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M.,... & Zeng, J. (2022). Global Carbon Budget 2021. *Earth System Science Data*, *14*(4), 1917–2005. https://doi.org/10.5194/essd-14-1917-2022

Global Carbon Atlas. (2022). CO_2 emissions. http://www.globalcarbonatlas.org/en/CO2-emissions

Hussain, M., & Dogan, E. (2021). The role of institutional quality and environment-related technologies in environmental degradation for BRICS. *Journal of Cleaner Production*, *304*, 127059. https://doi.org/10.1016/j.jclepro.2021.127059

Im, K. S., Pesaran, M., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53–74. https://doi.org/10.1016/s0304-4076(03)00092-7

Jahanger, A., Yu, Y., Awan, A., Chishti, M. Z., Radulescu, M., & Balsalobre-Lorente, D. (2022). The Impact of Hydropower Energy in Malaysia Under the EKC Hypothesis: Evidence From Quantile ARDL Approach. *SAGE Open*, *12*(3). https://doi.org/10.1177/21582440221109580

Jiang, Q., Khattak, S. I., & Rahman, Z. U. (2021). Measuring the simultaneous effects of electricity consumption and production on carbon dioxide emissions (CO2e) in China: New evidence from an EKC-based assessment. *Energy*, *229*, 120616. https://doi.org/10.1016/j.energy.2021.120616

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2–3), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen, S. (1995). *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press, Oxford.

Jutta, B., & van Zanden, J. (2020). Maddison Project Database, version 2020. "Maddison style estimates of the evolution of the world economy. A new 2020 update". https://www.rug.nl/ggdc/historicaldevelopment/maddison/publications/wp15.pdf

Kikoni, E., & Schiffbauer, M. (2020). The Economic and Social Impact of COVID-19. *WBs Outlook*, (148085). https://documents.worldbank.org/en/publication/documents-reports/documentdetail/562671590682452189/the-economic-and-social-impact-of-covid-19-air-pollution-challenges

Kisin, J., Mašović, A., & Ignjatović, J. (2021). Growing public debt as a result of the COVID-19 pandemic in the WBs region: The case of North Macedonia and Serbia. *Business economics*, *15*(2), 66-85. https://scindeks-clanci.ceon.rs/data/pdf/1820-6859/2021/1820-68592102066K.pdf

Knez, S., Štrbac, S., & Podbregar, I. (2022). Climate change in the WBs and EU Green Deal: status, mitigation and challenges. *Energy, Sustainability and Society*, *12*(1). https://doi.org/10.1186/s13705-021-00328-y

Kuznets, S. (1955). Economic Growth and Income Inequality. The American Economic, 45 (1), 1–28.

Lalic, D., Popovski, K., Gecevska, V., Vasilevska, S. P., & Tesic, Z. (2011). Analysis of the opportunities and challenges for renewable energy market in the WB countries. *Renewable and Sustainable Energy Reviews*, *15*(6), 3187–3195. https://doi.org/10.1016/j.rser.2011.04.011

Levin, A., Lin, C. F., & James Chu, C. S. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of Econometrics*, *108*(1), 1–24. https://doi.org/10.1016/s0304-4076(01)00098-7

Maddala, G. S., & Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, *61*(S1), 631–652. https://doi.org/10.1111/1468-0084.0610s1631

Marjanović, D., Beraha, I., & Simović, V. (2021). The Impact of Import, Export and FDI on the Economic Growth of the Western Balkans Countries. *Economic Analysis*, *54*(2), 20-29. https://doi.org/10.28934/ea.21.54.2.pp20-29

Matić, N., Skorup, A., & Radičević, M. (2022). Benchmarking analysis of key macroeconomic parameters of the WB countries. *International Review*, (3-4), 89-95. https://scindeks-clanci.ceon.rs/data/pdf/2217-9739/2022/2217-97392203089M.pdf

Mitić, P., Fedajev, A., Radulescu, M., & Rehman, A. (2023). The relationship between CO_2 emissions, economic growth, available energy, and employment in SEE countries. *Environmental Science and Pollution Research*, *30*, 16140–16155. https://doi.org/10.1007/s11356-022-23356-3

Mitić, P., Munitlak Ivanović, O., & Zdravković, A. (2017). A cointegration analysis of real GDP and CO_2 emissions in transitional countries. *Sustainability*, *9*(4), 568. https://doi.org/10.3390/su9040568

Mrabet, Z., & Alsamara, M. (2017). Testing the Kuznets Curve hypothesis for Qatar: A comparison between carbon dioxide and ecological footprint. *Renewable and Sustainable Energy Reviews*, *70*, 1366-1375. https://doi.org/10.1016/j.rser.2016.12.039

Özokcu, S., & Özdemir, Ö. (2017). Economic growth, energy, and environmental Kuznets curve. *Renewable and Sustainable Energy Reviews 72*, 639-647. https://doi.org/10.1016/j.rser.2017.01.059

Ozturk, I., & Acaravci, A. (2010). CO_2 emissions, energy consumption and economic growth in Turkey. *Renewable and Sustainable Energy Reviews*, *14*(9), 3220-3225. https://doi.org/10.1016/j.rser.2010.07.005

Pata, U. K., Dam, M. M., & Kaya, F. (2022). How effective are renewable energy, tourism, trade openness, and foreign direct investment on CO_2 emissions? An EKC analysis for ASEAN countries. *Environmental Science and Pollution Research*, *30*(6), 14821–14837. https://doi.org/10.1007/s11356-022-23160-z

Pesaran, M. H. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. Cambridge Working Papers in Economics No. 0435. https://doi.org/10.17863/CAM.5113

Sanfey, P., Milatović, J., & Krešić, A. (2016). *How the WBs can catch up. EBRD* Working Paper, 186. https://bg.uek.krakow.pl/e-zasoby/siec_lokalna/Ebor/w185.pdf

Sarkodie, S. A., & Ozturk, I. (2020). Investigating the environmental Kuznets curve hypothesis in Kenya: a multivariate analysis. *Renewable and Sustainable Energy Reviews*, *117*, 109481. https://doi.org/10.1016/j.rser.2019.109481

Skjærseth, J. B. (2021). Towards a European Green Deal: The evolution of EU climate and energy policy mixes. *International Environmental Agreements: Politics, Law and Economics*, *21*(1), 25-41. https://doi.org/10.1007/s10784-021-09529-4

Suki, N. M., Sharif, A., Afshan, S., & Suki, N. M. (2020). Revisiting the Environmental Kuznets Curve in Malaysia: The role of globalization in sustainable environment. *Journal of Cleaner Production*, *264*, 121669. https://doi.org/10.1016/j.jclepro.2020.121669

Tongsoongnern, P., & Lee, W. S. (2022). Influence of green transformational leadership on the workplace pro-environment behavior. *Economic Analysis*, *55*(2), 91-106. https://doi.org/10.28934/ea.22.55.2.pp91-106

Ummalla, M., & Goyari, P. (2020). The impact of clean energy consumption on economic growth and CO_2 emissions in BRICS countries: Does the environmental Kuznets curve exist? *Journal of Public Affairs*, *21*(1). https://doi.org/10.1002/pa.2126

UN. (2019). World Population Prospects: The 2019 Revision. United Nations Population Division, https://esa.un.org/unpd/wpp/

Villanthenkodath, M. A., Gupta, M., Saini, S., & Sahoo, M. (2021). Impact of Economic Structure on the Environmental Kuznets Curve (EKC) hypothesis in India. *Journal of Economic Structures*, *10*(1). https://doi.org/10.1186/s40008-021-00259-z

Voumik, L. C., Rahman, M. H., & Hossain, M. S. (2022). Investigating the subsistence of Environmental Kuznets Curve in the midst of economic development, population, and energy consumption in Bangladesh: imminent of ARDL model. *Heliyon*, *8*(8), e10357. https://doi.org/10.1016/j.heliyon.2022.e10357

World Bank, (2021). *WBs Regular Economic Report, No. 20, Fall 2021: Greening the Recovery*. https://elibrary.worldbank.org/doi/epdf/10.1596/36402

World Bank, (2022). *WBs Regular Economic Report, No. 22, Fall 2022: Beyond the Crises*. https://openknowledge.worldbank.org/handle/10986/38189

Yilanci, V., & Pata, U. K. (2020). Investigating the EKC hypothesis for China: the role of economic complexity on ecological footprint. *Environmental Science and Pollution Research*, *27*(26), 32683–32694. https://doi.org/10.1007/s11356-020-09434-4

Article history:	Received: 16.3.2023
	Revised: 4.5.2023
	Accepted: 8.5.2023