INVESTIGATING THE INTERPLAY OF ECONOMY AND ENVIRONMENT IN THE WESTERN BALKANS AND NEIGHBORING COUNTRIES USING THE VECM APPROACH

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ABSTRACT
The relationship between economic development and carbon dioxide emissions in the Western Balkans and the neighboring countries has been a subject of significant interest and study. Economic development, which involves increased industrialization, urbanization, trade, household, and energy consumption, is often associated with higher carbon dioxide emissions due to the burning of fossil fuels. Researchers have investigated how various factors such as economic growth, population size, energy mix, and technological advancements influence carbon dioxide emissions in different regions of the world. The purpose of this paper is to investigate the relationship between the carbon dioxide emissions and a set of economic factors which include gross domestic product, trade, household consumption and energy use, using the panel vector error correction model. The analysis includes nine countries from the Western Balkans and the neighboring countries and annual data for the period 2000 – 2019. The research uses panel unit root tests, cointegration testing and estimation of vector error correction model.
The model has confirmed that shocks that emerge in gross domestic product, total trade and household consumption increase the carbon dioxide emission in the long-term. The effect from the private (household) consumption is with the highest intensity, compared to other factors. A shock in trade causes a decline in carbon dioxide emissions in the long-term.

Keywords: *Carbon dioxide emissions, economic development, consumption, VECM*

JEL classification: *Q540, O1, E210, C32*

1. INTRODUCTION

The relationship between economic development and carbon dioxide emissions is pivotal in the context of climate change. Balancing economic growth with emissions reduction is a significant challenge, but it is essential for a sustainable and prosperous future. This is extremely important when comes to rising economies like the ones from the Western Balkans and neighboring countries. These nations have experienced various economic and political transitions in the past several decades, which have had implications on their environmental policies and carbon emissions. Exploring the key determinants of carbon dioxide emissions in the appointed region is a topic that has not been sufficiently explored, in authors' opinion, thus making this research a valuable contribution and a chance to fill a research gap regarding the intertwined long-term effects onto CO2 emissions in this part of the world.

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The analysis uses panel vector error correction model for estimation of the long-term equilibrium relationship and short-term dynamics of the variables, considering their interdependencies. Included variables that represent the complexity of the economic growth for each country are gross domestic product per capita, total trade, household final consumption per capita, and energy use. Understandably, CO2 emissions are included in the model. The panel dataset consists of observations for nine countries - North Macedonia, Serbia, Bulgaria, Greece, Montenegro, Albania, Bosnia and Herzegovina, Croatia, and Slovenia – annual data for period 2000 to 2019. Identifying the key determinants of carbon emissions could help in raising awareness about how these countries can achieve sustainable development in face of frequent economic, political, and social crises (Mitic et al., 2022).

Additional motivation for exploration of the dynamics between CO2 emissions and economic growth can be summed up in the following details:

Environmental impact - substantial economic growth causes environmental impact with high CO2 emissions that contribute to greenhouse effect, that leads to global warming, climate change, rising sea levels, extreme weather events and disruptions to ecosystems. These all create substantial economic and social costs;

Economic opportunities - reducing carbon emissions poses challenges and presents economic opportunities. The shift towards clean energy technology can create green jobs and new markets. Investing in green energy can stimulate economic growth and innovation;

Sustainable development goals - the United Nations Sustainable Development Goals (UNDP, 2023) recognize the interconnection between economic development and environmental sustainability. Goal 13, “Climate Action” points out the need to take immediate action to combat climate change and its impacts, while promoting sustainable economic growth and poverty reduction (Goal 1);

Global cooperation - addressing the relationship between economic development and CO2 emissions requires global cooperation. International agreements like the Paris Agreement aim to limit global warming by transition to a low-carbon economy.

This study adds to the existing scientific literature, which is a noteworthy contribution to the subject. It focuses on identifying significant economic factors impacting CO2 emissions in the Western Balkans and surrounding regions, a topic that requires more attention in future research. According to World Bank Lead Economist Richard Record (World, 2023) the current energy crisis has highlighted the need to accelerate the green transition across Europe, including the Western Balkans. The starting point would be acceleration towards carbon pricing and implementation of environmental fiscal measures that incentivize households and companies to shift toward lower carbon intensity. The first step towards green transition, according to the authors of this research, is to identify the key factors that determine the intensity of carbon emissions.

2. **LITERATURE REVIEW**

The relationship between carbon dioxide (CO2) emissions and economic growth has been a subject of extensive research in the field of environmental economics and sustainable development. Numerous studies have attempted to explore the complex dynamics between these two critical factors, particularly in the context of different regions and countries. In this literature review, we discuss some of the key findings and contributions of previous research related to the link between CO2 emissions and economic growth.

Goodness & Prosper (2017) conducted an analysis of 31 developing countries to examine the effect of economic development on carbon dioxide emissions. The results indicate that economic development has a negative effect on emissions when development is weak but a positive effect when development is substantial. According to their research, energy

consumption and population growth have the most significant impact on the growth of CO2 emissions.

Cedeborg & Snobohm (2016), based on a regression analysis of 69 industrialized countries and 45 poor countries, showed that there is a relationship between GDP per capita and emissions per capita. The correlation is positive, indicating that an increase in GDP per capita leads to higher CO2 emissions per capita.

Rambeli, et al. (2018) investigated the relationship between GDP, electricity production, net trade, electricity consumption and oil price on CO2 emissions in Malaysia using the Ordinary Least Square (OLS) method. The results suggest that GDP, electricity production, net trade and energy consumption affect CO2 emission positively, whereas the oil price affects emissions negatively.

In an analysis of 93 countries, Stolyarova (2013) demonstrated a cointegrated relationship between economic development and CO2 emissions in the short term but not in the long term. She also showed that the rate of growth of carbon dioxide emissions per capita increases proportionally with the rate of growth of GDP per capita.

Sharma (2011) showed that trade openness, GDP per capita, and energy consumption have positive effects on CO2 emissions. Urbanization has a negative effect on emissions in all countries regardless of their income levels. On a global level, GDP per capita and energy consumption are statistically significant determinants of carbon dioxide emissions, while urbanization, trade openness, and electricity consumption have a negative effect on emissions.

Among those researching the statistical relationship between economic development and CO2 emissions in the region, (Kokotovic, et al., 2015) conducted an analysis using a Vector Autoregressive (VAR) model on multiple variables for several European Union (EU) member countries, including Croatia, Bulgaria, Slovenia, and Greece. They confirmed the existence of a statistically significant relationship between energy consumption and CO2 emissions in the EU countries that became members after 2004, which includes Croatia, Bulgaria, and Slovenia.

Ahmad, et al. (2017) developed a model to test the Environmental Kuznets Curve theory in Croatia. According to the theory, as the economy develops over time, environmental pollution increases. However, when the economy reaches a certain level of wealth (income) per capita, pollution decreases. The study showed that the theory is valid in the long term, i.e., economic development leads to rising CO2 emissions up to a certain level, after which they start to decrease with prolonged economic growth.

Mitic, et al. (2020) assessed the causal relationship between CO2 emissions and the contributions of industrial production, services, and gross fixed capital in the total GDP of the Balkan countries. They discovered a strong link between the variables and concluded that all the factors have a long-term relationship with CO2 emissions. In a similar study involving countries from the Western Balkans, (Pejovic, et al., 2021) explored the relationship between economic development, energy consumption, and CO2 emissions using panel VAR analysis. The results reveal that most of the variations in CO2 emissions are determined by variations in GDP, but they conclude that growing GDP reduces CO2 emissions in the long term.

Mitic, et al. (2023) examined the relationship between CO2 emissions and GDP per capita in five Western Balkan countries using a VECM. The study provides evidence of a long-term cointegration between CO2 emissions and GDP per capita and revealed a short-run bidirectional causal relationship between CO2 emissions and GDP per capita. In the long run, no statistically significant causality from GDP per capita to CO2 emissions was found, but there was a statistically significant causal relationship from CO2 emissions to GDP per capita.

While most of the cited literature examines the effects that economic growth and development has on carbon emissions, very few authors (Mitic, et al., 2020, 2023) focus their attention on the Balkan countries in the recent period. In particular, the specified set of countries included in this analysis for the appointed period of observation and the selection of variables has not been a part of similar comprehensive study. The authors of this study consider this research as one that can fill the current research gap. The importance of this analysis can be seen by its findings and contribution to the policy makers by identifying the key determinants of CO2 pollution as a first step toward its slow eradication. Further step is creating an opportunity for development of green economies, especially in periods of energy crisis, which have severe effect onto the economies in the Wester Balkan and the neighboring countries. Reducing the level of carbon emissions and making economies less dependent on global energy sources should be one of the main topics of the policy makers agenda. Insights from this research may contribute as an incentive for further consideration.

3. DATA, METHODOLOGY AND EMPIRICAL RESULTS

This paper uses the panel vector error correction model to test the hypothesis regarding the long-term effects of the carbon dioxide emissions on economic growth. To represent the economic growth of one economy, several variables were used, such as:

- gross domestic product per capita (data in constant 2015 dollars, logarithmically transformed) - $ln(GDP)$;
- total trade as a sum of imports and exports of goods and services (data in constant 2015 dollars, logarithmically transformed) - $ln(TRADE)$;
- household final consumption per capita (private consumption per capita, logarithmically transformed) - $ln(CONSUMPTION)$;
- energy use (kg of oil equivalent per capita (primary energy), logarithmically transformed) - $ln(ENERGY)$;

CO2 emissions are expressed in metric tons per capita, thus the model is constituted of five variables - CO_2

The countries that are included in the panel model are: North Macedonia, Serbia, Bulgaria, Greece, Montenegro, Albania, Bosnia and Herzegovina, Croatia, and Slovenia. The observed period starts in 2000 and ends in 2019, so the model has a total of 180 observations. All the data is generated from the World Bank Database World Development Indicators. Their graphical presentation is in Figure 1.

CO2 emissions have different trends for each country. The most significant reduction is noticeable in Greece (from 8.74 in 2000 to 5.60 metric tons per capita in 2019 and Slovenia (from 7.31 in 2000 to 6.51 metric tons per capita). From the opposite side, Bosnia and Herzegovina and Montenegro have increased their emissions, producing as twice as much metric tons per capita in 2019 compared to 2000.

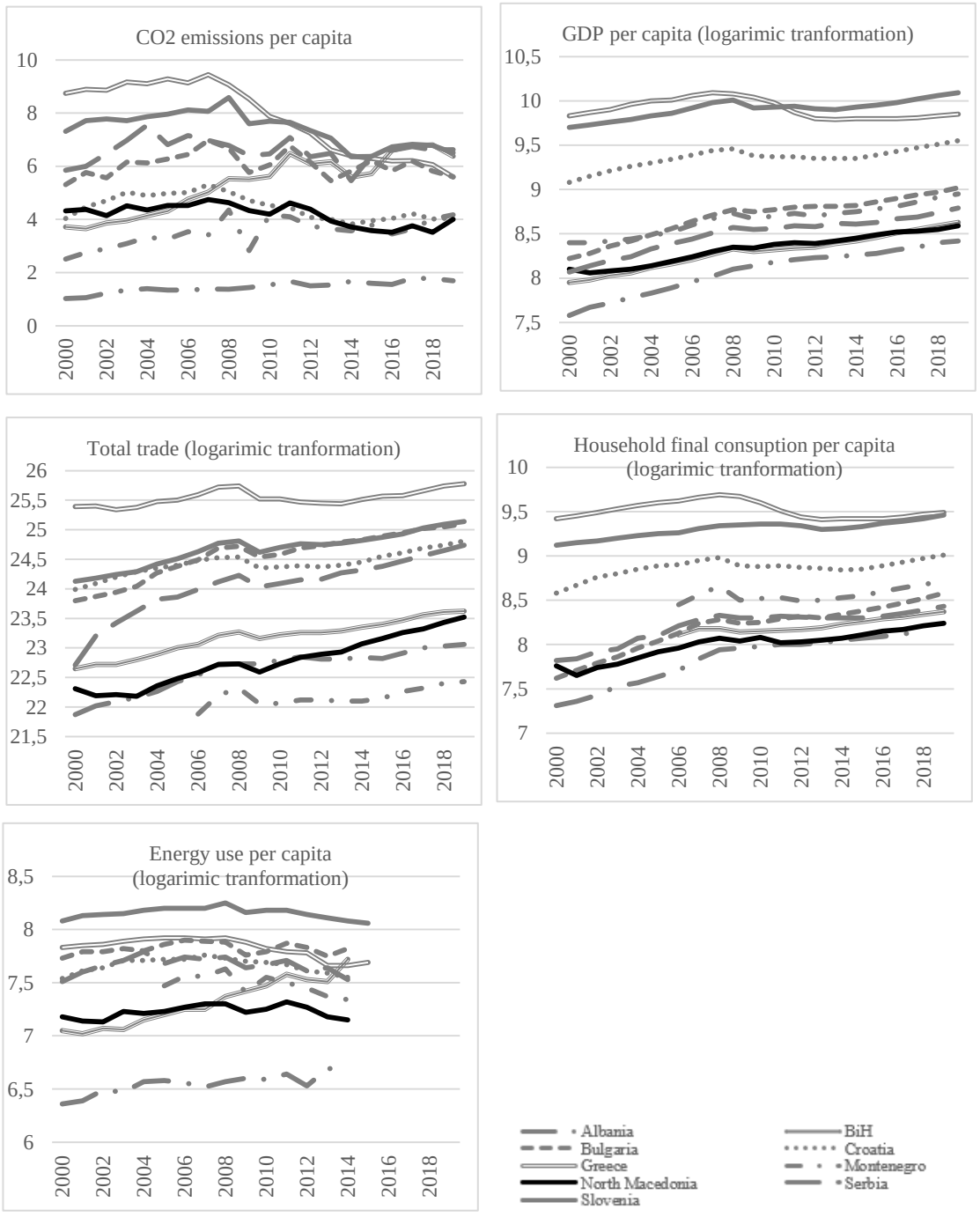
Regarding the GDP growth, most of the countries mark steady growth in the observed period. Greece, Slovenia, and Croatia have suffered certain instability in the period of the global economic crisis in 2008.

Total trade points increasing trends in all observed countries. Greece is the leading country, by the amount of total trade through the years, while Montenegro is the country with lowest amount of total trade. This is expected regarding the size of the countries and their economies.

Household final consumption per capita is the highest in Greece, followed by Slovenia, and Croatia (13,177 dollars, 12,879 dollars and 8,185 dollars per capita in 2019, respectively). Albania has the lowest consumption per capita (3,466 dollars per capita in 2018). Trends tend to show an increase in the households' final consumption in the observed period.

Energy used is the last of the explanatory variables that might influence CO2 emissions. All the countries have steady trends, though there is a significant difference between the countries. Slovenia is a country with the highest energy usage (3,175 kg of oil per capita in 2015), while Albania has only 808 kg of oil per capita in 2015.
Variables, presented as time series, are tested for their stationarity by using unit root tests. This process is needed to avoid potential spurious relationships and to determine whether vector autoregressive model or vector error correction model is more appropriate for modeling of the determinants of the CO2 emissions. The results from the panel unit root tests are presented in Table 1.

Figure 1: Presentation of variables used in the model



Source: World Bank (2023), graphical presentation by authors

Since all the variables present trends in their dynamics, the stationarity tests are performed for individual intercept and trend. Also, since data are missing for some time periods and variables, unbalanced panel requires to use test that assume individual unit root process. In Table 1 results from ADF and Philip Perron tests are presented.

Table 1: Results of the panel unit root tests (p-values)

Variable	ADF test		PP test	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$
$ln(GDP)$	0.7463	0.8916	0.9492	0.0183**
$ln(TRADE)$	0.6943	0.0003***	0.1303	0.0000***
$ln(CONSUMPTION)$	0.3631	0.0030***	0.9708	0.0000***
$ln(ENERGY)$	0.6799	0.0000***	0.0005***	0.0000***
CO_2	0.1011	0.0001***	0.0027***	0.0000***

***Significant at 0.05; *** Significant at 0.01*
(Source: Authors' calculations)

To bring the conclusion about the stationarity of the data, results from both tests are considered. Variables are not stationary in their original form, and they need to be differentiated to become stationary. Lag selection determines the number of time lags for the used model. Both LR test statistic and Final prediction error suggest five time lags (detailed results from the Lag Order Selection Criteria are available upon request). Another essential information for estimation is the number of cointegrating relationships. The Unrestricted Cointegration Rank Test indicates one cointegration equation at 0.05 level. Thus, with all variables integrated of order one and one cointegrating relationship confirmed, vector error correction model $VECM$ is more suited for estimation.
The $VECM$ with $p = 5$ time lags, five endogenous variables and one cointegrating relationship is presented in the equation:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{5} \Gamma_i \Delta y_{t-1} + \varepsilon_t$$

And the cointegrating relationship:

$$\Pi y_{t-1} = \alpha + \sum_{i=1}^{5} \beta_i y_{it} + u_t$$

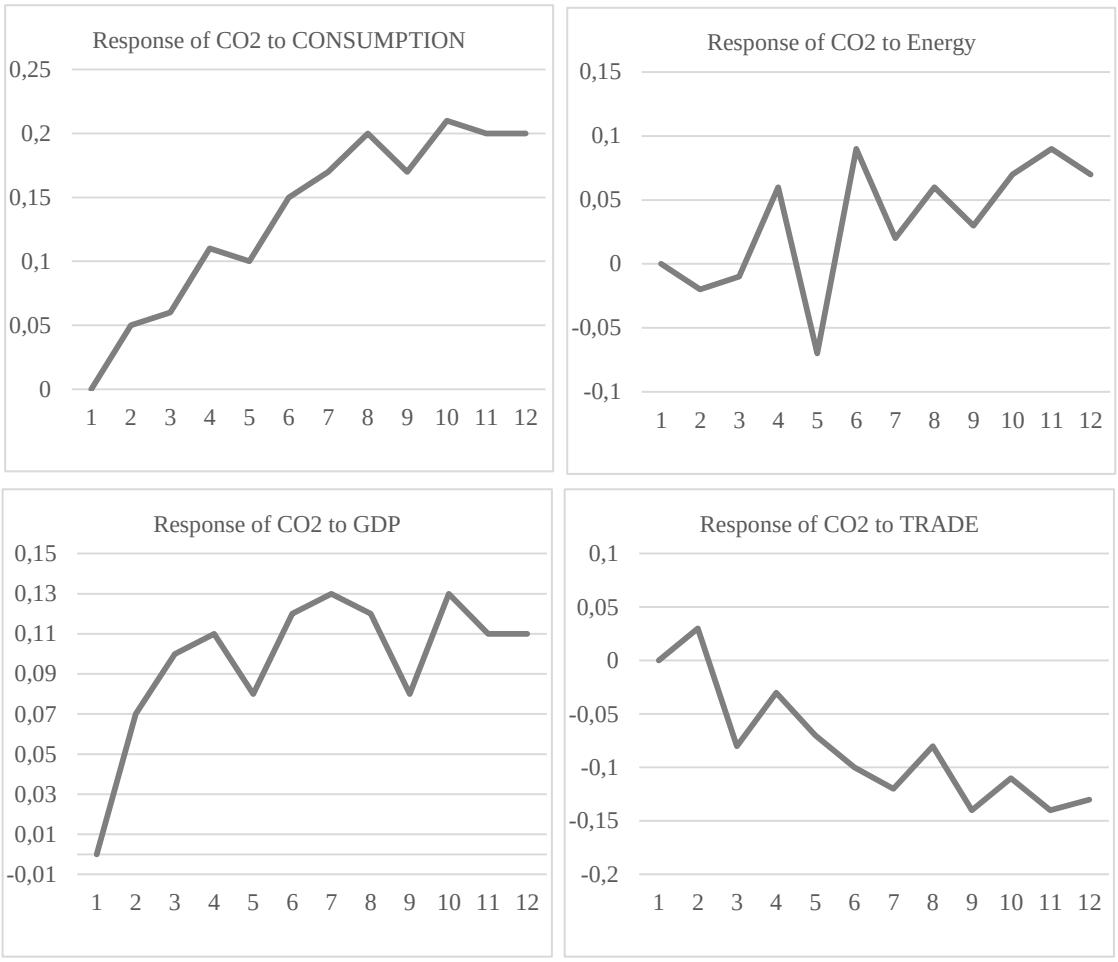
Where:

- y_t is a 5×1 vector of endogenous variables at time t;
- Δy_t is the first difference of the vector y_t at time t;
- Π is a 5×5 matrix of cointegrating relationships, showing the long-term equilibrium relationship among the variables;
- Γ_i us a 5×5 matrices of coefficients for each of the p lags;
- ε_t is a 5×1 vector of white noise error terms at time t, assumed to be normally distributed with zero mean and constant variance;
- α is a 5×1 vector of constants in the cointegrating relationship;
- β_i is a 5×1 vector of coefficients on the i-th variable in the cointegrating relationship;
- u_t is the cointegration error term, which is assumed to be stationary.

The $VECM$ helps analyze the long-term relationship among the variables and the short-term dynamics in their adjustments toward the long-term equilibrium, as captured by the

cointegrating relationship. The error correction term u_t reflects the speed at which deviations from the long-term equilibrium are corrected.
The estimated VEC model reproduced the impulse response functions presented in Figure 2. Impulse responses trace out the responsiveness of the dependent variable in the VEC model to shocks to each of the variables (Brooks, 2014). The analysis focuses on responses that the CO2 emissions have when certain shocks are present in the independent variables for the following 12 periods.
Most prominent response is the one that is caused by the household consumption. Innovations to unexpected rise in consumption have positive impact on the CO2 emissions. The effect does not die, on the opposite, it continues to grow further on.

Figure 2: Impulse response functions



(Source: Calculations and graphical presentation by authors)

A shock of one standard deviation in energy use causes positive effect onto CO2 emissions. The intensity of this reaction is smaller than the one caused by the consumption. In the first three years the effect is near to zero, and a more significant increase comes after the fifth period.
GDP causes steady and positive response to CO2 emissions. A shock of one standard deviation in GDP always increases the emissions of carbonite dioxide, and this increase is persistent through the twelve periods horizon.
The last effect is one caused by total trade. Increasing shock in trade has negative impact on the CO2 emissions, starting from the third period and with increased intensity, this negative trend continues until the end.

The results from the impulse response functions confirm that the economic factors are important determinants of carbon dioxide emissions in the Western Balkans and the neighboring countries.

4. DISCUSSION

The results from the estimated model manage to confirm that household consumption, energy use, GDP per capita and trade have statistically significant and long-term effect on carbon emissions. Private household consumption seems to have the leading impact on CO2 emissions, since according to the impulse response function, this effect starts from the second year and continues to grow throughout the forecast period. The effect is in accordance with expectations and similar results can be found in research by Druckman & Jackson (2015) and Lai, et al. (2020). Particularly Druckman & Jackson (2015) state that households are accountable for almost three-quarters of the global carbon emissions and understanding the drivers of these emissions is important for making progress towards low carbon future. Lai, et al., 2020 consider that it is important to discuss the effects that household consumption have on carbon emissions in order to achive the goal of energy conservation and emission reduction. Their results confirm that most household carbon emissions come from direct energy, food, medical and daily necessities consumpition.

In addition to the previous findings, it is important to mention that consumerism contributes to increased personal consumption causing greater use of energy and materials, leading to increased waste from purchased products (Orecchia & Zoppoli, 2007). Personal consumption has a considerable influence on economic growth, which is why governments try to stimulate consumption to foster economic development. Yet, this comes with a significant negative impact on the environment and increases carbon dioxide emissions.

The presented model confirms a long-run relationship between energy consumption and carbon emissions. Impulse response function shows that innovations to unexpected rise in energy use causes increase in CO2 emissions, particularly after the fifth year. In the first three years there are no significant increases in carbon emissions. The increase in CO2 emissions caused by energy increase is the expected determinant and few other studies have confirmed this finding. Abbassi et al. (2021) performed panel cointegration model and confirmed long-run relationship between energy consumption and CO2 emissions, indicating that high energy consumption represents a barrier for improvement of the environmental quality in the long run in eight Asian countries. Energy consumption as one of the key causes for increased carbon emissions was confirmed by Sharma (2011), Akadiri et al. (2019) and Salari et al. (2021).

Economic growth is expected to contribute to increased CO2 emissions. Rise in industrial production, construction of new buildings and infrastructure require higher energy demand across sectors, and in the analyzed set of countries most industries rely heavily on fossil fuels. The impulse response function reports fluctuating and constantly growing long-term effect on carbon emissions caused by an increase in GDP per capita. Growth rate of domestic product per capita and the growth rate of CO2 emissions corresponds to conclusions from Pejovic, et al., (2021), Wang et al. (2019), while Salari, et al. (2021) had findings that showed an inverted-U shape relationship between CO2 emissions and GDP, providing evidence to validate ne Evnironmental Kuznets Curve.

According to the impulse response function, the impact of a positive shock in total trade value leads to a reduction in carbon dioxide emissions in the long term. Akin (2014) obtained a similar result in an analysis of the relationship between energy use, economic development, and trade openness as variables influencing carbon dioxide emissions. He concluded that trade openness can reduce carbon dioxide emissions in the long run, although a positive

change in trade openness leads to an increase in carbon dioxide emissions in the short term. The results are not surprising since increase in trade can reduce CO2 emission through several mechanisms such as: global supply chain efficiency, where country specialize in production of goods and services for which they have comparative advantages, or the scenario of carbon leakage mitigation where emission intensive industries relocate to countries with less strict environmental regulations. Of course, this only keeps the emission on the same level or higher, globally. Other mechanisms include technological transfer, access to clean energy sources, or import of cleaner goods. A study from Wang et al. (2023) finds that the impact of trade on carbon emissions is heterogeneous, where trade openness leads to increase in carbon emissions, while trade diversification leads to reduction in carbon emissions. This study used data from OECD and G20 countries. It can be concluded that when comes to countries from the Western Balkan and the surrounding countries increase in trade can contribute to reduced CO2 emissions, mostly due to the imported goods instead of producing the same goods at emission intensive industries.

4. **CONCLUSION**

Economic growth has been one of the most important goals set by the policy makers in the Western Balkan and neighboring countries. After decades of turbulence and political instability, achieving and sustaining this goal is not an easy task. The governments of these economies were ready to compromise between the economic growth and development, which brings employment and social stability on one hand, and on the other hand there is the significant rate of pollution, an unwanted and yet present side effect of increased economic activity. After decades of compromises now is probably a good starting point for those same policy makers to reconsider their policies and to start developing viable alternatives for reduction of CO2 emissions and development of new green economies.

The first step towards reduction of CO2 emissions is identifying the key economic determinants that have impact on these emissions. The findings of this study confirm that household consumption, energy use, gross domestic product and trade have statistically significant impacts on carbon emissions. It would be important for policymakers to know that increase in household consumption, energy use and gross domestic product also causes increase in CO2 emissions, while increase in trade causes reduction in carbon emissions. These findings are particularly important for the selected countries since they seem to be not sufficiently researched in the previous literature.

This study brings its theoretical and practical contributions. Its theoretical contribution comes by enriching the literature regarding the main determinants of carbon emissions in a group of countries that was underrepresented in previously performed research. This initial analysis can act as a catalysator for further and more complex research regarding the dynamics of CO2 and economic growth. Practical contributions of this study come from its main findings, and they can serve as potential guidelines for creation of environmental and economic policies that will carry the message for reduced emissions and their benefits. Since the energy usage was one of the determinants of CO2 emissions, governments should consider a transition to renewable energy by promotion of solar, wind, hydro, or geothermal power, they can incentivize investments in renewable energy infrastructure and research and development, and ultimately, they can implement polices to phase out or reduce the use of fossil fuels. Regarding the household consumption there are few measures than can be considered such as energy efficiency standards for buildings, appliances and vehicles, carbon pricing mechanism like carbon taxes for reduction of carbon emissions, sustainable transportation where investments in public transportation, cycling infrastructure and pedestrian friendly urban planning can take effect. A lot can be done with education and awareness where the public should be educated about the climate change and the importance

of reducing greenhouse gas emissions and to encourage sustainable behaviors and choices in both households and businesses.

When overall economy is considered, there is much that can be done for reduction of carbon emissions: promotion of circular economy by reducing waste and encouraging recycling and reuse and supporting sustainable production and consumption practices, sustainable agriculture with reduced emissions and reduced food waste, reforestation, and afforestation with implementation of sustainable forestry management practices. Engagement in international climate agreements and partnerships could help in coordination of effort for CO2 reduction and it could contribute to promotion of technology transfer and financial assistance to help developing countries transition to cleaner energy sources. When comes to trade, encouraging trade agreements could alleviate the overall carbon emissions in certain national economies.

Overall, this research contributes to the understanding of the linkages between economic growth and environmental sustainability in the Western Balkans and neighboring regions. It highlights the urgent need for policy interventions that promote sustainable development pathways, ensuring economic prosperity while safeguarding the environment for future generations.

Future research could expand on this study by incorporating additional variables and refining the analysis to capture a more comprehensive understanding of the drivers of CO2 emissions.

In conclusion, the results of this study underscore the importance of integrating environmental considerations into economic policymaking. Achieving sustainable economic growth in the Western Balkans and neighboring regions necessitates a transformative approach that balances prosperity with environmental preservation. Promoting renewable energy, improving energy efficiency, and adopting low-carbon technologies are key strategies to mitigate the impact of rising energy demand on the environment and combat climate change. Policymakers should prioritize investments in clean technologies, energy efficiency, and sustainable infrastructure. Moreover, public awareness campaigns and education initiatives can foster a culture of responsible consumption and environmental stewardship.

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