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Original Research

Forecasting Greenhouse Gas Emissions and Sustainable Growth in Montenegro: a SVAR Approach

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Abstract

This paper uses a recursive structural vector autoregression method to investigate and forecast the linkage and causality between greenhouse gas emissions (GHG) and Gross Domestic Product (GDP) in Montenegro empirically from 2006:1 to 2015:12, and out-of-sample 24-month horizon forecasting from 2016:1 to 2017:12. It is the first time that GDP and GHG are modeled and predicted for the economy of Montenegro using the SVAR approach. We examine an individual SVAR model to forecast GDP. The model uses GDP growth and GHG emissions expressed in CO_2eq by sectors as endogenous determinants. The GHG sectors are energy, industrial process, agriculture and land, and waste. Alternative forecasting scenarios, impulse response functions and variance decomposition of forecast errors are interpreted in combination with expectations. We reveal that the sectors of agriculture and land and energy contribution explain 83.41% of the movement of GDP at the 24-month horizon.

The paper provides macroprudential policymakers with an in-depth understanding of the GHG emissions expressed in CO_2eq by sectors play in sustainable growth in Montenegro.

Keywords: Macroeconometric Forecasting, GDP, GHG emissions, SVAR

Introduction

In the last few decades, the unfavorable impact of economic growth on environmental quality began gaining popularity as emissions of carbon dioxide (CO_2) increased, combined with global warming and climate change. These problems became a topic of thorough research in academic circles.

Understanding the nexus CO_2 emissions and economic growth helps economies in formulating energy policies and developing energy resources in sustainable ways [1]. Montenegro ratified the United Nations Framework Convention on Climate Change (UNFCCC) after regaining independence in 2006 and became a non-Annex-1 party to the Convention on January 27th, 2007. The Kyoto Protocol was ratified on March 27th, 2007, and Montenegro became a non-Annex-B party on September 2nd, 2007. By ratifying the UNFCCC and the Kyoto Protocol, Montenegro joined countries sharing the same concerns and undertaking an active role in international efforts to address climate change (CC) [2].

At the 21st Conference of the Parties (COP21) of the UNFCCC, held in Paris from November 30th to

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December 12th, 2015, the Paris Agreement was adopted as a global agreement on climate change, which seeks to strengthen the global response to the threat of climate change [3]. The main goal was determined by the countries "to keep the increase in the global average temperature well below 2ºC compared to the pre-industrial period, and to make efforts to limit the temperature rise to 1.5ºC above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (Art. 2). The Paris Agreement recognizes that the long-term objectives set out in Articles 2 and 4.1 will be achieved over time and therefore supports the aggregation of overall and individual ambitions over time.

On October 5th 2016, the threshold for the entry into force of the Paris Agreement was achieved. The Paris Agreement entered into force on November 4th, 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55% of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depositary. To this date, 189 Parties have ratified the Agreement, out of 197 Parties to the Convention [4]. Nationally determined contributions (NDCs) are submitted every five years to the Secretariat of the UNFCCC.

The Obama administration accepted the Paris Agreement in August 2016, without submitting the instrument to the Senate for its advice and consent to ratification. The U.S. accordingly became a party to the Agreement when it entered into force in November 2016. In June 2017, President Trump (i.e. the Government of USA) notified the UN Secretary-General of its decision to withdraw from the Agreement, which took effect on November 4th, 2020, following article 28 (1) and (2) of the Agreement [5]. However, President-elect Biden announced the USA will reenter the Paris Agreement as early as February 2021.

Today, the EU leads in implementing Paris climate commitments, as a global green player. The European Green Deal, presented on December 11th, 2019, provides a roadmap for the EU to become the world's first climate-neutral continent by 2050. The Green Deal presents the necessary investments and available funding tools and explains how to ensure a fair and comprehensive transition, covering all sectors of the economy, especially transport, energy, agriculture, buildings, and industries such as steel, cement, ICT, textiles, and chemicals [6].

The European Union is already doing well in reducing greenhouse gas emissions while maintaining economic growth. Emissions in 2018 were 23% lower than in 1990, while the Union's GDP grew by 61% in the same period [7]. On March 4th 2020, as part of the European Green Deal, the European Commission adopted a legislative proposal for a European Climate Law that sets the ambitious objective for the EU to become climate-neutral by 2050 (a legally binding EU-wide common target of net-zero GHG emissions by 2050 i.e. emissions of GHG must not exceed removals) and establishes a framework for achieving that objective. On September 17th 2020, the Commission amended the proposal to introduce a target of 55% reduction of the EU's GHG emissions by 2030 compared to 1990, based on the related climate target plan [8], which was endorsed by the European Council on December 11th 2020, and called on the co-legislators to adopt the European Climate Law swiftly.

As a member of the UN, Montenegro has committed itself to achieve the U.N. Sustainable Development Goals (SDGs), while in parallel negotiating full membership in the European Union (EU) since June 2012. Of utmost importance are the negotiations in Chapter 27- Environment and climate change, opened in December 2018., while the planned fulfillment of obligations from the said Chapter (i.e., regulations, institutions, investments, infrastructure, administrative capacities), is deemed a precondition for dynamic progress in meeting SDGs, especially goals related to a green, low-carbon economy and environmental protection. Chapter 27 is connected with 40 targets of 17 SDGs [9].

In the areas of air quality and climate change, Montenegro continues to fully align with relevant EU directives, and is expected to continue doing so by regularly taking measures to decrease the level of air pollution, especially in the areas where the threshold EU values are already exceeded. Montenegro is working on the alignment of the EU legislation concerning EU Emission Trading Scheme (ETS), and is obliged to follow, report and verify GHG emissions.

On October 11th, 2017, the Parliament of Montenegro enacted a law ratifying the Paris Agreement, thus, undertaking to contribute to GHG emissions reduction globally [10]. Montenegro has committed itself to reduce GHG emissions by at least 1,572 kt CO_2eq to the level of 3,667kt CO_2eq or less. Montenegro's contribution to international efforts to address CC issues, expressed through the Intended Nationally Determined Contribution (INDC) to reductions in GHG emissions, is set at a minimum of 30% by 2030 compared to 1990 as the baseline year [11]. Montenegro became a party to the Paris Agreement in December 2017 and submitted an INDC. Besides, it is essential to note that Montenegro has initiated a review of the Nationally Determined Contribution.

With the presentation of the Third National Communication on Climate Change (TNC), Montenegro is once again fulfilling its international obligations under the UNFCCC. This paper examines, forecasts and shows the causality among the GDP and greenhouse gas (GHG) emissions, expressed in CO_2 eq by sectors as endogenous determinants. The sectorial division is energy, industrial processes, agriculture and land, and waste.

This essential evidence shows that governing GHG is critical in promoting sustainable growth. The main implications of this study suggest that energy and agriculture and land sectors are crucial in governing the emission of GHG in Montenegro.

It is the first time that a SVAR prediction of GDP and GHG emissions, is realized for the economy of Montenegro. This paper suggests using a structural vector autoregressive model, employing time series data from 2006:1 to 2017:12 for Montenegro to evaluate and compare the empirical performance of various forecasts of GDP [12].

As regards the nexus of economic growth and CO_2 emissions, in the literature, there are three points of view: a) economic growth causes CO_2 emissions; b) there is a bi-directional nexus between CO_2 emissions and economic growth, and c) there is no causation between economic growth and CO_2.

Diverse approaches and techniques have been studied to show the nexus between sustainable growth and CO_2. The analysis of dynamic interrelationships of output and energy environment nexus has been examined by many authors, applying vector error correction models (VECM), panel vector autoregression (PVAR), ARDL cointegration and Granger tests, FMOLS, DOLS and impulse response function analyses [13, 14, 15-22, 23-28].

Forecasting and examining the impact of GHG on sustainable growth in Montenegro are essential for the creation and implementation of a low-carbon development strategy for the next decade. In other words, the rationale for this research is to help Montenegro cope with climate changes and develop its economy in a wise way that benefits both citizens and their natural environment and ecosystems. Factors of greenhouse gas emissions in advanced and transitional countries have been a topic of many empirical and theoretical studies. The relationship of CO_2 emissions and sustainable growth has been intensive since CO_2 is emitted in a number of ways such as burning of oil, coal, gas, petrol and also deforestation [29-38]. Several authors investigated relationships between economic growth and CO_2 emissions using different methodologies.

A number of studies has been conducted to investigate the relationship between energy consumption, CO_2 emissions, and economic development [39-42]. Many researchers examined the nexus between CO_2 emissions (environmental pollution) and economic growth using the environmental Kuznets curve hypothesis: Azomahou et al. [43] found a stable relationship between economic growth and CO_2 emissions by using a nonparametric kernel-based estimator to emissions for a panel of 100 countries from 1960 to 1996.

Bildirici [44] found a bi-directional link between economic growth and CO_2, using panel autoregressive distributive lag model (ARDL), Fully Modified OLS Canonical Cointegration Regression, and Dynamic OLS. Song et al. [45] show that the amount of GHG and energy utilization reduce based on future planning in China, from the perspective of both the country and related sectors. Antonakakis et al. [46] found a bi-directional causal link between total economic growth and energy use, by studying the dynamic interrelationship based on output-energy-environment nexus, CO_2 emissions, energy use and economic growth in the period 1971-2011. Aye and Edoja [47] showed that the correlation between CO_2 and economic growth is positive for developed economies (in the high growth regime), but negative for developing economies (in the low growth regime), by using the dynamic panel threshold framework.

Mladenovic et al. [48] used a support vector machine, genetic programming, and artificial neural network to forecast the CO_2 emissions and economic growth. They found that the nexus between CO_2 emissions and economic growth was essential. Sun et al. [49] studied the linkage between the CO_2 emissions and the low-carbon economy using extreme learning machine and particle swarm optimization methods. They found a high forecasting performance. Bengochea-Morancho et al. [50] explored the nexus between economic growth and CO_2 emissions and have shown there is a difference between advanced and other countries. Lo et al. [51] found a gap between productivity growth trends with and without CO_2 emissions. Cialani [52] tested the linkage between CO_2 emissions and income by using the time series data in Italy and found a positive nexus between CO_2 emissions and economic growth. Sharma [53] examined the determinants of CO_2 emissions in 69 countries using dynamic panel data and found out that GDP per capita and urbanization were the two main determinants of CO_2 emissions. The results of Franklin and Ruth [54] for the USA, using a time series of 200 years, showed a positive linkage in per capita CO_2 emissions with economic growth. Apergis and Payne [55] suggest renewable resources reduce harmful emissions.

Chaabouni et al. [56] examined the linkage between economic growth, health expenditures, and CO_2 emissions. They have shown that there exists a bidirectional link between health expenditures, economic growth, and CO_2 emissions except in not advanced countries. Chiu [57] investigated the relationship between real income, energy, CO_2 emissions, and investment, and the outcomes of this paper have shown that clean energy usage successfully impacts real income.

Finally, Mitic et al. [58] used DOLS and FMOLS for a series of annual data of 17 transitional economies from 1997 to 2014 to analyze the relationship between real GDP and CO_2 emissions and showed a long-term cointegrating relationship among CO_2 emissions and real GDP, i.e., a GDP increase of 1%, results in an increase of CO_2 emissions of about 0.35%.

On the other hand, Ozturk and Acaravci [59] examined the long-run causal relationships among economic growth, energy consumption, CO_2 emissions, and employment in Turkey, using data from 1968 to

Table 1. Total GHG emissions expressed in CO_2 eq by sectors, 1990, 2017 and projections for 2030.

Year		Energy ($Gg\ CO_2eq$)	Industrial production and use of products ($Gg\ CO_2eq$)	Emission sinks in agriculture and land use	Waste ($Gg\ CO_2eq$)	Total emissions with sinks ($Gg\ CO_2eq$)	Total emissions without sinks ($Gg\ CO_2eq$)	Sinks ($Gg\ CO_2eq$)
Gas inventory	1990	2,339.68	1,701.52	2,472.79	171.19	6,685.19	6,685.19	0.00
		35%	25%	37%	3%	100%		
	2017	2,370.32	351.42	1,961.18	253.89	4,936.81	4,936.81	0.00
		48%	7%	40%	5%	100%		
Projection	2030*	2,815.00	308.00	129.00	266.00	**3,518.00**	**3,321.00**	-197.00
		80%	9%	4%	8%	100%		
		85%	9%	4%	8%		100%	-6%

Source: GHG inventory of Montenegro, 2019.

2005. Using ARDL they found that neither energy consumption per capita nor CO_2 emissions cause GDP growth. Nevertheless, Mardani et al. [1] confirmed the existence of a long-run bidirectional relationship between energy consumption and CO_2 emissions in both the new and old EU countries.

Given our vast literature review, we found no similar study that considered GHG emissions and economic and sustainable growth, especially using GHG emissions by sectors. Montenegro, working at the same time on UN and EU agenda, should be analytical about energy conservation policies to design appropriate strategies to deal with the reduction of CO_2 emissions without impacting economic growth. Understanding the nexus between CO_2 emissions and economic growth will assist the Montenegrin economy in formulating energy policies and developing energy resources in sustainable ways.

Material and Methods

We estimate a recursive structural VAR identified model of GDP. The model identifies the endogenous determinants: GDP and sectorial GHG emissions. We find that the performance of the stochastic simulation and static solution outperforms all SVAR models [60, 61].

The objective of this paper shows that governing GHG emissions is crucial for the sustainable development of Montenegro. *Ceteris paribus*, our main statement is that Montenegro should take appropriate steps in lowering the emissions of GHG, especially in the sector of energy and agriculture and land. We used a SVAR model, because as Narayan et al. [62] define it, a model is 'structural' only if we can use it to predict the effects of deliberate policy actions or of 'major' changes in the economy (positive or negative shocks). According to Sims [63] a structural model, is a model we can use in decision making. Identification is the interpretation of historically observed variation in data in a way that allows the variation to be used to predict the consequences of an action not yet undertaken.

Even though GDP determinants have been studied to a great extent, we reveal a significantly wider knowledge gap. First, conceptual specification, based on which empirical examinations of GDP determinants are analyzed, combined with GHG is not prevailing in combining theory and empirical analysis. Second, we identify a structural VAR model recursively. It has not been applied to the Montenegrin economy. VARs turn out to be one of the key empirical tools in modern macroeconomics, and they allow one to model macroeconomic data informatively [64].

According to the Montenegro GHG inventory presented in the Third National Communication on Climate Changes [2], in 2017 the largest share of emissions came from the energy sector (48%, with a growing trend in the structure), representing an increase of 13% since 1990. The energy sector is followed by agriculture and land (40%), industrial production and use of products (7%), representing a significant decrease from 1990, and waste (5%). The total emission with sinks is 100%. In the following table, you can also see the projections for 2030, showing a significantly growing trend of emissions in the energy sector (80%), followed by a decrease of emissions in the other observed sectors.

The most significant impact on emissions is produced by electricity and heat (including an aluminum production plant). Emissions from traffic are on the rise and are expected to continue growing, given the development of tourism in Montenegro. The main contribution to emissions from industrial processes in Montenegro is given by perfluorocarbons (PFCs) from aluminum production, which is a by-product of electrolysis.

Given that projections of GHG emissions by 2030 are increasingly concentrated in the energy sector, it is possible to analyze in more detail the dynamics of GHG emissions by sectors and its impact on GDP (potential future impact based on previous relations in the twelve years 2006-2017).

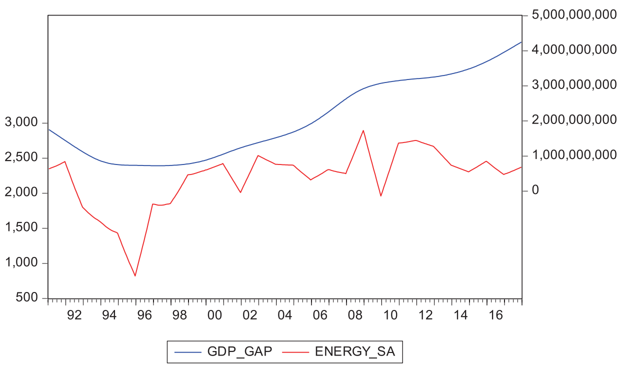

Fig. 1. GDP_GAP and Logarithm of Energy.

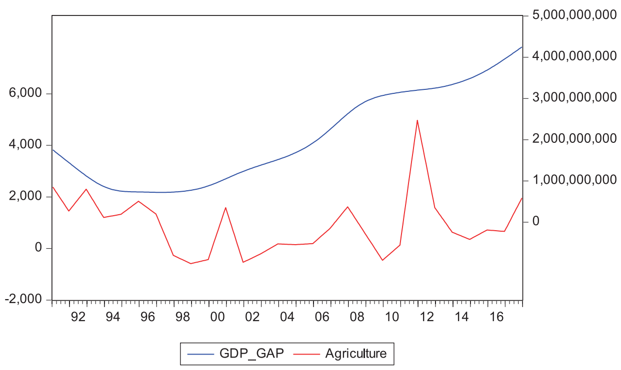

Fig. 2. GDP_GAP and Agriculture and Land.

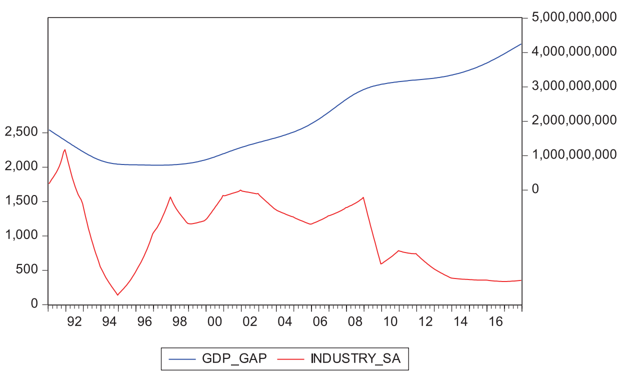

Fig. 3. GDP_GAP and Logarithm of Industrial Process.

Results and Discussion

Based on the following equation (1), we formed our equation that shows parameter estimates and the main characteristics of the models. The identified recursive SVAR model is as follows:

$$gdp\_gap_t = \beta_0 + \beta_1 log(energy)_t + \beta_2 log(agriculture\&land)_t + \beta_3 log(industrial\_processes)_t + \beta_4 log(waste)_t + u_t \quad (1)$$

...where gdp_gap_t denotes the *gdp_gap* rate, *log* natural logarithm denotes a constant elasticity,

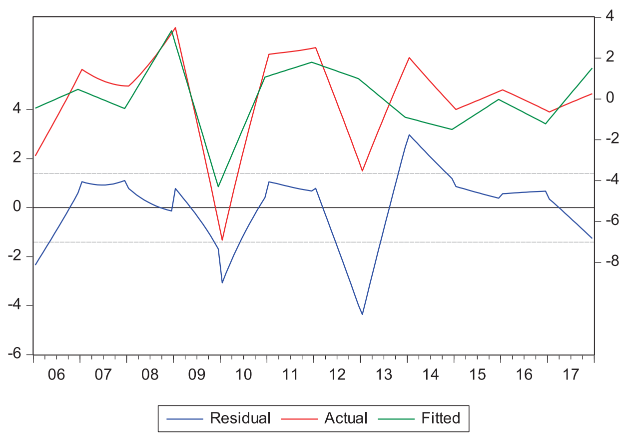

Fig. 4. Actual, fitted, and residual.

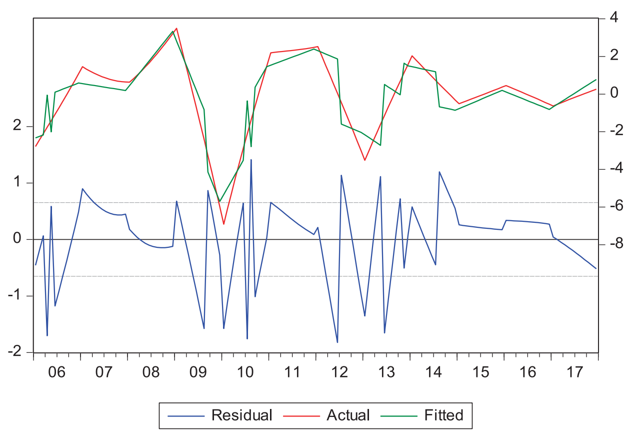

Fig. 5. Actual, fit., and residual with dich.

Table 2. Simple Multivariate Regression of GDP with Dichotomous Variables.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.164286	4.172175	0.758426	0.4495
LOGAGRI	0.000206	6.35E-05	3.238851	0.0015
LOGE	0.005700	0.000551	10.34030	0.0000
LOGINDUS	0.000666	0.000157	4.243730	0.0000
LOGW	-0.065137	0.018704	-3.482562	0.0007
D2006	-2.027628	0.352732	-5.748352	0.0000
D2010	-2.794245	0.289306	-9.658434	0.0000
D2013	-3.371636	0.221644	-15.21197	0.0000
D2014	1.814330	0.243773	7.442695	0.0000
R-squared	0.892111	Mean dependent var		-0.010379
Adjusted R-squared	0.885717	S.D. dependent var		1.929412
S.E. of regression	0.652252	Akaike info criterion		2.043690
Sum squared resid	57.43339	Schwarz criterion		2.229303
Log likelihood	-138.1457	Hannan-Quinn criter.		2.119112
F-statistic	139.5354	Durbin-Watson stat		1.251093
Prob(F-statistic)	0.000000			

Source: Authors' estimates.

Table 3. VAR Lag Order Selection Criteria.

Lag	LogL	LR	FPE	AIC	SC	H.Q.
0	-2901.091	NA	5.60e+15	50.44985	51.04329	50.69075
1	-1491.185	2576.724	239167.7	26.57216	27.75905	27.05397
2	-1128.125	632.2265	707.2766	20.74353	**22.52387***	**21.46624***
3	-1092.526	**58.92163***	**595.1445***	**20.56079***	22.93458	21.52441
4	-1086.922	8.792250	845.6914	20.89521	23.86244	22.09974

* indicates lag order selected by the criterion Source: Authors' estimates.

$log(energy)_t$ the natural logarithm of energy, $log(agriculture\&land)_t$ the logarithmic state of agriculture and land, $log(industrial\_processes)_t$ the logarithmic value of industrial processes, *log*(*waste*)*t* denotes the natural logarithm of waste.

The time series are stationary based on visual inspection, correlograms, and unit root tests. Based on the below graph, we see graphically that gdp_gap and energy move close together, except there appears to be a break in 1996, and after 2009 the gap widens.

The same tightness is noticed between gdp_gap and agriculture and land.

The relatedness between gdp_gap and the industrial process seems to be very close from 2006 till 2010.

Simple multivariate regression shows a high linkage among the dependent and independent variables. The R^2 shows 48.48% connectivity among the variables just at the beginning.

This can be confirmed from the actual, fitted, and residual graph below, but the model still needs dichotomous variables.

After adding the appropriate dichotomous variables (2006, 2010, 2013, and 2014), we get the following actual, fitted, and residual graph. It seems well-fitted, and the R^2 equals 89.21%, indicating that the variables explain almost 90% of the movement of GDP in Montenegro. The multivariate regression with dichotomous variables looks as following:

The SC and HQ VAR lag order selection criteria suggest 2 lags, while L.R., FPE, and AIC suggest 2 lags. After doing autocorrelation tests, we decide to go with 3 lags, VAR (3).

Table 4. Roots of Characteristic Polynomial.

Lags	LM-Stat	Prob
1	13.11732	0.9750
2	8.904671	0.9987
3	4.201667	1.0000
4	4.835334	1.0000
5	3.921168	1.0000
6	6.982494	0.9999
7	8.285785	0.9993
8	4.802020	1.0000
9	8.546036	0.9991
10	9.365479	0.9980

Probs from chi-square with 25 df. Source: Authors' estimates.

Table 5. VAR Residual Serial Correlation L.M. Tests.

Lags	LM-Stat	Prob
1	13.11732	0.9750
2	8.904671	0.9987
3	4.201667	1.0000
4	4.835334	1.0000
5	3.921168	1.0000
6	6.982494	0.9999
7	8.285785	0.9993
8	4.802020	1.0000
9	8.546036	0.9991
10	9.365479	0.9980

Probs from chi-square with 25 df. Source: Authors' estimates.

In the meantime, the test performed in Table 4 shows that VAR (3) is stationary, and we can move further with our analysis.

Based on Fig. 6, there appears to be no autocorrelation. This is confirmed by the L.M. test in Table 5.

The null hypothesis of no serial correlation cannot be rejected as long as up to 10 lags the *p*- value is higher than 5%.

Our VAR (3) estimates with 3 lags is employed for further analysis. We estimate from 2006:1 till 2015:12 and leave 2016 and 2017 for out-of-sample forecasting performances.

In the following figure we show the forecasting performance of deterministic simulation and dynamic solution.

Fig. 7 reveals important results that show that under deterministic simulation and dynamic solution, which uses forecasted and not real values, our model is able to forecast well the endogenous variables of our VAR (3) except agriculture and land (which turns back in the second quarter of 2017).

In case we perform the forecasting using a fan chart, we can observe the forecast and graphical representation of forecast uncertainty around it. It allows for error, coefficient, and the uncertainty associated with explanatory variables in the model. Moreover, it demonstrates a confidence interval of the forecast for every period in the forecast horizon. The darkest area shows the confidence interval assuming economic conditions stay the same. The lightest area is 90% confidence interval. It is symmetric, depending on the types of risks, the model we adopted for the variance, and the assumptions regarding the exogenous variables. Bands expand with forecast horizon and stabilize on unconditional confidence interval. If the errors are normal and the model is linear, the fan chart will be symmetrical around the mean: 1s.e. bounds correspond to ~60% confidence interval, and 2 s.e. bounds correspond to 95% confidence interval. In the meantime, the errors are bootstrapped, i.e., selected randomly from the estimated residuals, and coefficient uncertainty expands the bounds. As we get more data to calibrate the model, we should expect the confidence interval to shrink.

So far, we have not seen any causality among the variables, GDP and GHG emissions expressed in CO_2eq by sectors. This would lead us to impulse responses and variance decomposition.

The response of GDP_GAP to agriculture and land, and all other GHG emissions expressed in CO_2 eq, a shock goes through oscillations, from positive to negative. The positive shock of agriculture and land increases the GDP in the first 10 months to 0.28, then decreases sharply to -0.18 after 2 years. How can we interpret the above results? In the beginning, when the agriculture and land greenhouse gas increase, as a result of higher investments in unmanaged agricultural production, the GDP increases, but only seasonally. At the same time, the medium-run dynamic impact of the innovation of greenhouse gases produced by agriculture and land causes the GDP to decrease sharply.

A much more substantial impact is noticed in the sector of energy in the first half of the year, after being hit by the energy shock. The energy sector is the primary source of anthropogenic GHG emissions. The energy sector includes all activities referring to the combustion of fuels (solid, liquid, gaseous, and biofuels) in stationary and mobile sources, as well as fugitive emissions from fuels. Fugitive emissions occur during the production, transmission, processing, storage, and distribution of fossil fuels. As a result of investments in the sector of energy, the GDP_GAP increases by 0.43% in the first 6 months. After 12 months, the dynamic effects of the greenhouse gas emissions from energy reduce the GDP_GAP to 0.02, and after 17 months to -0.24.

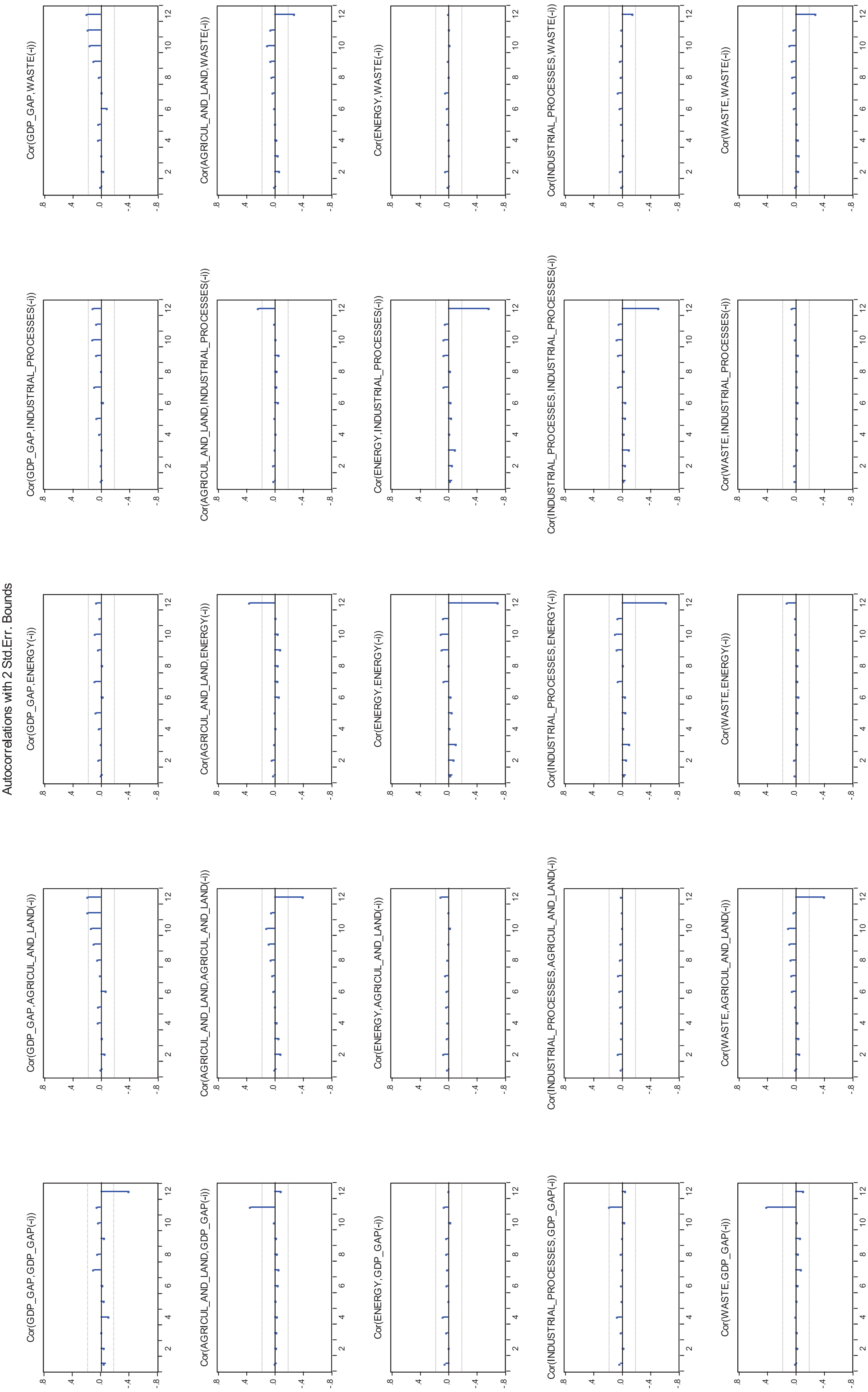

Fig. 6. Autocorrelations with 2 Standard error bounds.

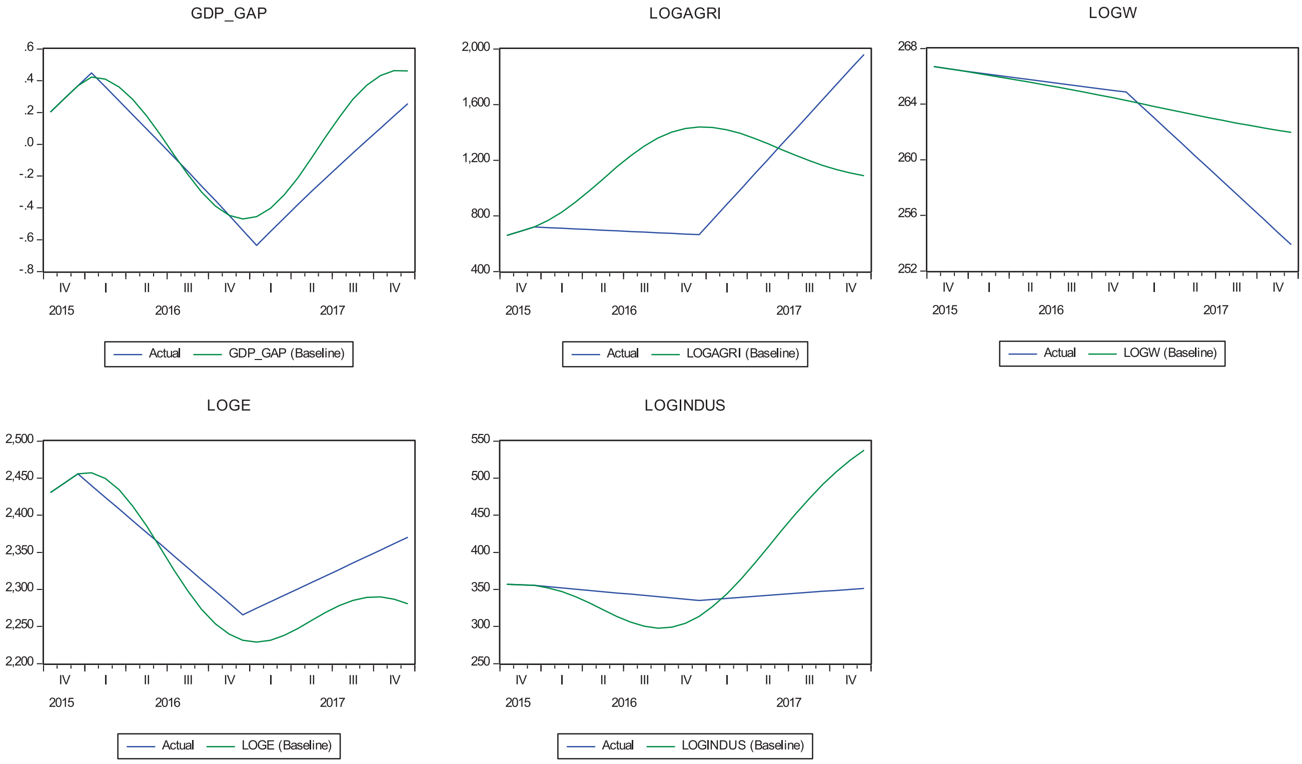

Fig. 7. Deterministic simulation and dynamic solution (2006:1-2017:12).

The response of GDP_GAP to the industrial process has the same pattern of movement as in the previous greenhouse gas shocks, but it is stronger. After the investments made in the Montenegrin economy by the industrial sector, the GDP_GAP increases to 0.12 in the first 7 months. From the 7th month, the GDP_GAP decreases to 0.00 after 26 months gradually.

Interestingly, the GDP_GAP decreases at the very beginning from a waste shock to -0.02 in the first 3 months. After this point, the dynamic effects show a smooth increase in the GDP_GAP to 0.07 after 14 months, and then a slight decrease again. Why the increase from the 3rd to the 14th month? The waste management takes advantage of the disposal and treatment of solid municipal waste, wastewater management, and waste incineration in the period 3-14 months. Still, after this period, the methane (CH_4) emissions resulting from the disposal and treatment of solid municipal waste and the emissions of nitrogen sulfide (N_2O) cause the GDP_GAP to decrease.

For policymakers, it is of high value to retreat the variance decomposition in time dynamics.

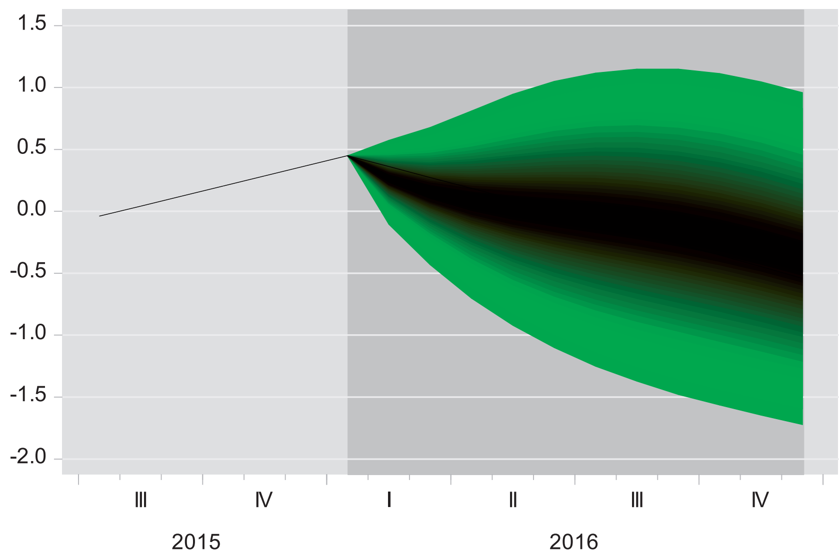

Fig. 8. Fan chart of GDP_GAP.

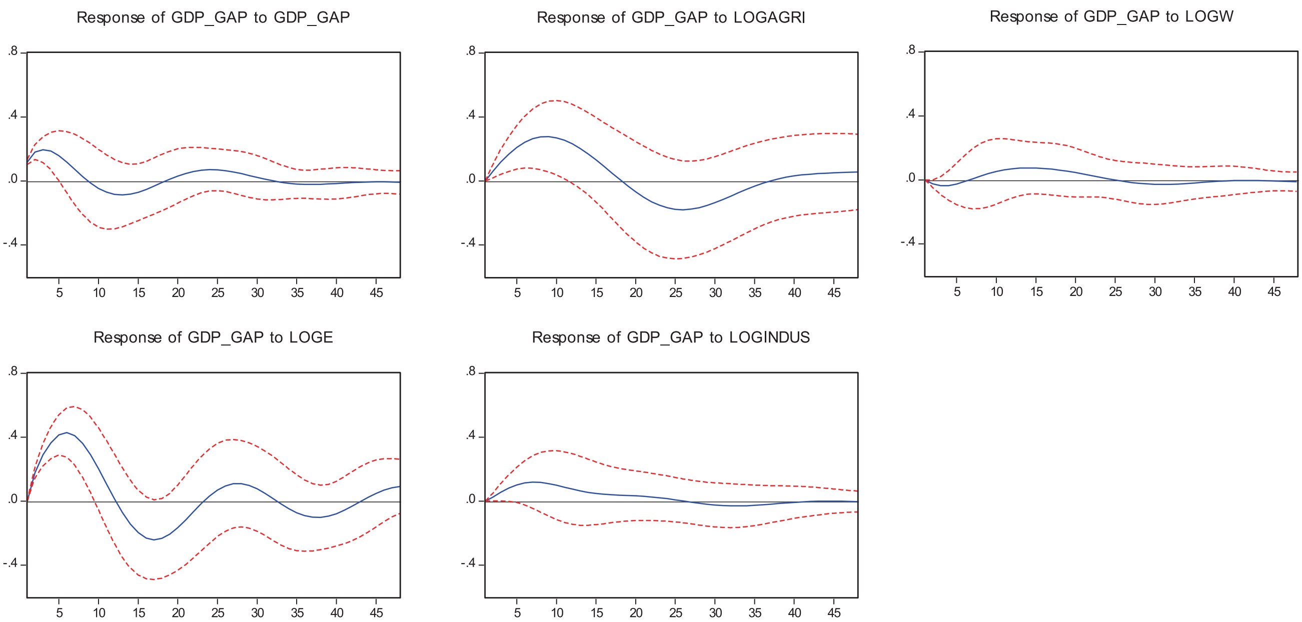

Fig. 9. GDP_GAP Impulse response to Cholesky One S.D. Innovations±S.E.

The forecast error variance of GDP is mostly the result of shocks to itself at short horizons 98.88%. After a 6 month-horizon, the contribution of agriculture and land shocks to the movement of GDP increase to 13.43%. The contribution of energy shocks jumps to 62.27%, while the contribution of industrial and waste rises to 3.71 and 0.16, respectively. We notice from the above decomposition that the energy sector plays a crucial role in the forecast error variance of GDP. It is essential to mention that the contribution of agriculture and land increases its impact on the decomposition of GDP over time, and it reaches 29.63% at the end of the 24-month horizon. Only the sectors of agriculture and land and energy contribute with 83.41% to the movement of GDP at the 24-month horizon. In the SVAR model (structural vector autoregressive model), it is possible to analyze the impact of CO_2 emissions by sectors on the movement of GDP in Montenegro. In the research that covered the period 2006-2017, the following conclusions were reached regarding the variables, i.e., the factors that most determine the future dynamics of GDP. Emissions from the energy sector mainly influence the decomposition of GDP variance: the contribution of emissions from the energy sector

Table 6. Variance decomposition of GDP_GAP.

Period	S.E.	LOGAGRI	LOGE	LOGINDUS	LOGW	GDP_GAP
1	0.118216	0.734594	0.043001	0.007794	0.331353	98.88326
2	0.288097	2.575477	36.04288	0.941471	0.258412	60.18176
3	0.473273	5.673452	49.82823	1.852263	0.351436	42.29462
4	0.654160	8.326933	56.47889	2.594508	0.303623	32.29605
5	0.824407	10.87296	60.33863	3.207592	0.221949	25.35887
6	0.974274	13.43029	62.27358	3.713899	0.159286	20.42295
7	1.098156	16.05205	62.74830	4.128601	0.139003	16.93205
8	1.194678	18.75932	62.07943	4.467530	0.170205	14.52351
9	1.265667	21.51692	60.53404	4.743852	0.254493	12.95069
10	1.315555	24.21476	58.41523	4.964168	0.388781	12.01706
11	1.350398	26.66816	56.09669	5.127984	0.565459	11.54171
12	1.376562	28.65124	53.99817	5.230669	0.771967	11.34795

Source: Authors' estimates.

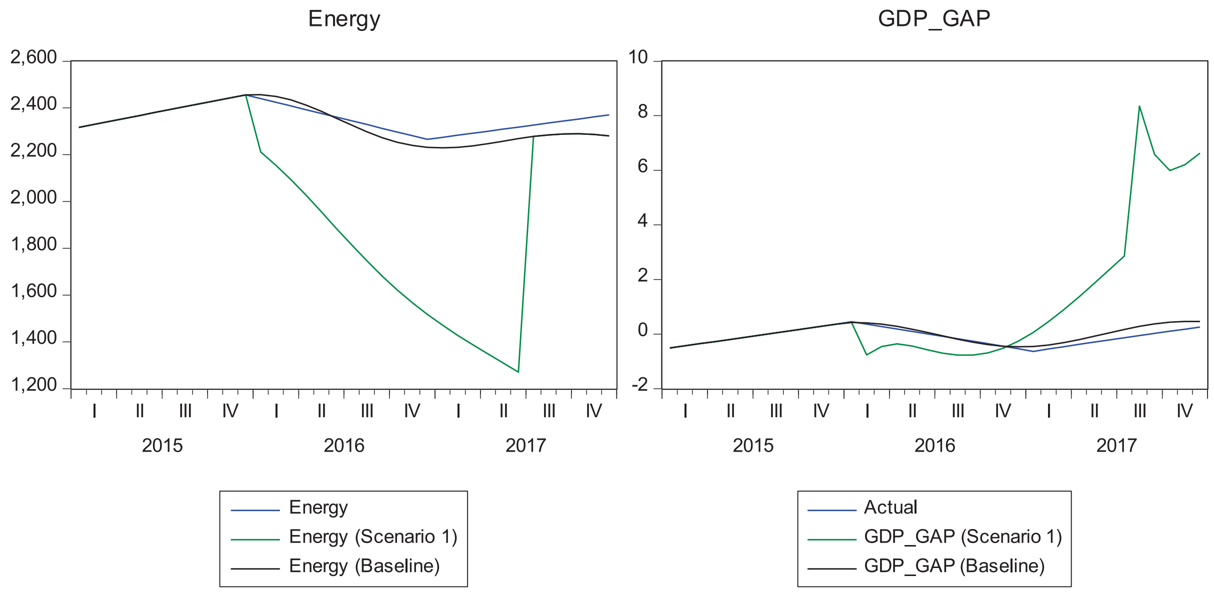

Fig. 10. Forecasting of GDP_GAP: alternative scenario of energy decrease from -10 to -44%.

to GDP ranges from 37.04% to 62.1% in the dynamics of the first year of the forecast. The contribution of emissions from the agriculture and land management sectors ranges from 2.5% to 28.6% in the dynamics of the first year of GDP forecast error variance.

The contribution of emissions from the industrial sector to GDP grows from 0.94% to 5.23% in the dynamics of the first year of the forecast, which is in line with the projections of the relative growth of emissions in the energy sector relative to the industrial sector (gradual limitation of stationary emissions in the industry). The contribution of waste sector emissions to GDP growth is also growing, which confirms the thesis that the rate of recycling and reuse of waste does not increase with satisfactory dynamics concerning the absolute growth of waste.

Since the central policymakers for sustainable development are interested to see sensitivity scenarios, we insert the decrease of energy GHG from -10% to -44%, in the period of 2016:1-2017:6 under deterministic-dynamic solution. This scenario is based on the following key points: a) the expected increase of investments into the energy sector, given the need to produce energy from renewable sources, which implies large investments and b) that the energy sector has the biggest share of GHG emissions, as stated in the GHG inventory table and its explanation.

As can be seen in the graph, in the scenario of reducing CO_2 emissions from the energy sector from 2,434.87 Gg CO_2eq to 1,270.43 Gg CO_2eq (44%) in the period from the first to the eighteenth month of the forecast, GDP would grow dynamically, respectfully from 0.06% to 8.4%. In other words, as early as one year after reducing emissions, the low-carbon economy would begin to record dynamic and strong growth (with a reduction in the remediation of environmental degradation costs). In other words, the stated reduction of emissions significantly stimulates the dynamics of GDP growth and changing the sector's contributions to growth. Based on the analyzed time series, the energy sector increases its share in emissions, at the same time, most significantly contributing to the dynamics of GDP growth, compared to other sectors relevant to emissions. Antonakakis et al. [46] did a similar study to ours, which revealed that the effects of the various types of energy consumption on economic growth and emissions are heterogeneous on the various groups of 106 countries in the sample, and also found a bidirectional causality between total economic growth and energy consumption. Han et al. [32] argue that bidirectional short-run causality between CO_2 emissions and GDP are the signal to develop a low-carbon economy needed to address the dilemma between economic development and carbon emissions. Hossain and Chen [41] showed that economic structure and emission elements are liable to increase carbon emissions in the industrial sector, which implies that the energy policymakers should be more mindful. Nathaniel et al. [65] suggest that nonrenewable energy increases emissions which negatively affects environmental quality**.** In order to achieve environmental sustainability, which is in line with the SDG 7, adoption of renewable energy sources like biogas, geothermal, solar, wave power, and so forth, is needed. Sebri and Salha [26] confirm bidirectional causality flow between economic growth and renewable energy consumption for BRIC countries,validating the feedback hypothesis. Cerovic Smolovic et al. [66] results confirm the existence of a positive relationship between economic growth and renewable energy consumption in the long term in old and new EU Member States.

As can be seen in Fig. 10, in case we hypothetically decrease the GHG emissions in the energy sector, from 2,434.87 Gg CO_2eq to 1,270.43, in the period from

January 2016 till June 2017, the GDP_GAP increases sharply from 0.062 in January 2017 to 8.355 in August 2017.

We decreased the energy sector, and the forecasted GDP increased sharply thus, implying that government regulations are essential. The impulse response findings reveal that the response of GDP to a shock in energy, industrial processes, agriculture and land use, and waste management is significant. The variance decomposition of GDP is moved mostly from energy and agriculture and land use. The energy refers to the combustion of fuels (solid, liquid, gaseous, and biofuels) in stationary and mobile sources, as well as fugitive emissions from fuels. The agricultural sector refers to enteric fermentation, fertilizer management, cumulative and other sources of gas from the soil, and biomass burning emissions. Mandatory application of the sustainable forest management requirements is crucial in forestry sector.

Investing in clean, renewable energy sources can prove to be beneficial for economic growth, which is compatible with the findings of Chiu and Chang [67]. As we have shown, simply by reducing GHG emissions in the energy sector, in the long run we can boost the GDP growth rate.

Conclusions

With the indispensable need for sustainability and the ever-growing need for environmental quality, some adjustments in the economy's structure are needed. Montenegro should focus on innovative development by increasingly investing in technological innovation and should promote clean production, renewable energy, energy efficiency and circular economy. The Government should not only provide policy and financial support by aligning environmental laws and regulations with the EU and its enforcement but should also improve education on green growth for which the implementation of new ideas and strategies that are based on green investment is necessary.

Structural vector autoregression, from an empirical viewpoint, reveals valuable information for policymakers. We selected a model, aggregating vital macroeconomic variables to forecast GDP and GHG emission in Montenegro. The forecasting performance of deterministic-dynamic solution reveals an excellent forecasting performance, even though it uses forecasted values, adding errors to the forecast. On the other hand, the stochastic-static performs a significant prediction of our VAR (3) model.

We find that among the performance of the forecasts, the stochastic simulation – static solution has the best performance, having the baselines within the confidence bands, thus, ensuring us that the VAR(3) can predict the GDP based on GHG emissions expressed in CO_2eq by sectors as endogenous determinants. This essential evidence shows that governing GHG is critical in promoting sustainable growth. The main implications of this study suggest that energy and agriculture and land use sectors are crucial in regulating the emission of GHG in Montenegro. In other words: the underlying objective of the paper relates to governing GHG emissions of energy and agriculture and land use as conducive to sustainable growth in Montenegro.

In sum, the empirical conclusions of this paper provide macroprudential policymakers with an in-depth understanding of the role GHG emission determinants play in sustainable development and the growth of the Montenegrin economy. Future research avenues might include sign restrictions, Bayesian, and factor augmented VARX approaches of other pollutants to get a better macro-econometric picture of the GHG emissions and sustainable growth.

The objective of this paper was that Montenegro should take appropriate steps in lowering the emissions of GHG, especially in the sector of energy and agriculture and land use. Given the presented points of view regarding the nexus of economic growth and CO_2 emissions, we have demonstrated that, for Montenegro, there is a bi-directional nexus between CO_2 emissions and economic growth.

Based on the obtained results, it is recommended that the policymakers in Montenegro should strive to adopt and implement strategies that should focus on adopting environmentally friendly technologies, i.e. best available techniques to decrease CO_2 emissions. Policymakers should continue controlling GHG emissions, as well as introduce incentives to reduce emissions, i.e. green financing measures, in order to meet their emission reduction targets, as per international agreements.

In addition, given that Montenegro has ratified the Paris Agreement, and that is simultaneously working on both the EU and UN agenda, obligations arising from Chapter 27 – Environment and climate change, as well as 40 targets of SDGs with which this Chapter is associated, shows progress, and positively affects the Montenegrin economy, demonstrated through the GDP growth rate.

During the period 2017-2030, Montenegro's goal is to continue to reduce GHG emissions without jeopardizing economic growth. Some of the measures that should help in achieving that goal are: (i) Energy sector: energy efficiency measures, increased share of energy from renewable sources, energy production and distribution sector modernization; (ii) Industry sector: improvement of industrial technologies and processes; (iii) Transport: promotion of electric vehicles usage; (iv) Agriculture: supporting organic production, as well as the usage of organic manure; (v) Land use: limiting quantities for felling in state and private forests, reducing burned areas on an annual basis and (vi) Waste sector: reducing the share of bio-waste and promoting recycling/composting.

Conflict of Interest

The authors declare no conflict of interest.

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