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FACTORS AFFECTING AGRICULTURAL EMISSIONS IN THE WESTERN BALKANS: PANEL DATA ANALYSIS

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Abstract

Reducing agricultural emissions is one of the most important issues in global policy, which is becoming increasingly challenging as time goes on. To address this, our study explores the major determinants of agricultural emissions in the Western Balkans while considering gross domestic product (GDP), agriculture value added, trade, energy use in agriculture, and foreign direct investments (FDI). The empirical results based on panel data analysis showed that GDP does not have a significant impact on emissions. Agriculture value added has had a significant and negative impact on nitrous oxide emissions and a significant and positive impact on methane emissions. Trade has significantly negatively affected nitrous oxide and methane emissions, while energy consumption has had a significant and positive impact on nitrous oxide and methane emissions. FDI has had a significant and positive impact on methane emissions, while its effect on nitrous oxide emissions was not statistically significant. This article can serve as a basis for further research on the topic.

Keywords: agricultural emissions, panel data analysis, Western Balkans, nitrogen, methane

1. INTRODUCTION

Climate change is expected to adversely affect the Western Balkans region (Regional Cooperation Council, 2018). The temperature increases of at least 1.2ºC are expected in the short term, while a further increase of 1.7 – 4.0°C is projected by the end of the century, depending on the effort in GHG emission reduction. The projection of precipitation is less confident, but in general, it is expected that precipitation will continue to decrease in summer and increase in winter (Müller & Hofmann, 2022). This will likely result in a significant decrease in yield quality and quantity of key staple crops, especially maize, in the period April-September during the dry years. The period June-August is particularly sensitive when maize needs irrigation in case of a drought.

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Compounding the problem, the irrigated land in Serbia, the main producing area in the Western Balkans, is very small, with only 3.7% of arable land (Kresovic et al., 2014). This implies that irrigation is essential for successful maize production in the entire region. Apart from crop production, climate change will also adversely affect livestock production. In the case of heat, there will be an elevated degree of mortality and outbreaks of parasite infections while milk yield will decrease (Liu et al., 2019; IPCC, 2022). To cope with climate change and achieve sustainability goals, agricultural production should be transformed (Vuković et al., 2018).

The adoption of sustainable and climate-resilient farming practices in the region includes many possible responses, such as agro-technical measures, housing for livestock, institutional adaptation measures, raising awareness, proper coordination through representative bodies, simultaneous implementation of adaptation measures at governmental and stakeholder levels (a bottom-up approach), etc. To achieve that aim, the Western Balkans countries introduced the Green Agenda, aligned with the goals of the European Green Deal (European Commission, 2020).

Keeping in mind the institutional efforts and the fact that 65% of the Western Balkan region's population considers climate change a threat (Balkan Barometer Council, 2019), this study focuses on the factors that influence agricultural emissions. The article is composed of four sections. Section 2 outlines methods and data collection. Section 3 presents the results, firstly, it discusses the agricultural nitrous oxide and methane emissions per capita in the region compared to the EU's countries, and secondly, it examines the most important determinants influencing the agricultural emissions. Conclusions and policy implications are discussed in Section 4.

2. MATERIAL AND METHODS

Our sample consists of five Western Balkan countries – Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia – over the 14-year period (2006-2019). The survey period has been chosen in accordance with the accessibility of the data. The first year of the research corresponded with an independence referendum held in Montenegro. To get a balanced panel, i.e., to observe each unit in every period, 2019 was the last observed year.

Based on previous extensive research on this topic, we have selected determinants of agricultural emissions, namely GDP, agriculture value added, FDI, trade, and energy consumption. Using the following equations, we analysed the impact of those factors on agricultural emissions:

$$\ln X_{it} = \alpha + \beta_1 \ln GDP_{it} + \beta_2 \ln A_{it} + \beta_3 \ln FDI_{it} + \beta_4 \ln T_{it} + \beta_5 \ln E_{it} + \mu_i + \lambda_t + u_{it} \quad (1)$$

$$\ln Y_{it} = \alpha + \beta_1 \ln GDP_{it} + \beta_2 \ln A_{it} + \beta_3 \ln FDI_{it} + \beta_4 \ln T_{it} + \beta_5 \ln E_{it} + \mu_i + \lambda_t + u_{it} \quad (2)$$

where X_{it} represents agricultural nitrous oxide emissions per capita in the country i in the period t; Y_{it} represents agricultural methane emissions per capita in the country i in the period t; GDP represents GDP per capita in the country i in period t; A

represents agriculture value added in the country *i* in period *t*; *FDI* represents FDI as a proportion of GDP in the country *i* in period *t*; *T* represents trade as a proportion of trade in the country *i* in period *t*; *E* represents energy use in agriculture; μ_i and λ_t represent cross-sectional and period-specific effects (random or fixed), respectively; and u_{it} represents a random error of the model.

This research includes data obtained from the Food and Agriculture Organization (FAO, 2023) and the World Bank Statistical data base (World Bank, 2023) (Table 1). The expected impact of explanatory variables on the dependent variables is presented in Table 1. Namely, it is expected to find a positive impact of economic growth and energy consumption on nitrous oxide and methane emissions (De Vita et al., 2015) and a negative influence of foreign direct investments, trade, and agricultural value added (Zhang et al., 2017; Mahmood et al., 2019; Prastiyo et al., 2020).

3. RESULTS AND DISCUSSION

Examining agri-food systems GHG emissions by country relieved differences among observed Western Balkan and European countries. Most of region's countries have significantly reduced farm gate emissions over the period 2006-2019 and increased GHG emissions. In addition, two trend can be distinguished across Western Balkan and the EU countries. Most Balkan countries have significantly increased pre- and post-production emissions as well as agrifood systems emissions, while an opposite trend is observed in the EU countries – Netherland and Denmark (Figure 1). Despite the reduction, developed EU countries are far ahead in total GHG emissions compared to Western Balkan region.

Out of five Western Balkan countries the lowest agricultural nitrous oxide emissions per capita, in a 14-year average, are recorded in Montenegro (190.1 kg CO_2-eq) while the highest emission average is recorded in Serbia (458.5 kg CO_2-eq) (Figure 2). In the same period, the lowest average of methane emissions was documented in Bosnia and Herzegovina (431.4 kg CO_2-eq), while the highest emission average was documented in Albania (720.1 kg CO_2-eq) (Figure 3). For comparison's sake, the 14-year average (2006-2019) of agricultural nitrous oxide and

Table 1. Variables, definitions, and data sources

Explanatory variables	Definitions	Source	Expected relationship
	Dependent variables X and Y		
GDP	GDP per capita (constant 2015 US$)	WB	Positive
A	Agriculture forestry, and fishing, value added (% of GDP)	WB	Negative
FDI	Foreign direct investment, net inflows (% of GDP)	WB	Negative
T	Trade (% of GDP)	WB	Negative
E	Energy use in agriculture, terajoule	FAO	Positive

Source: The author' composition

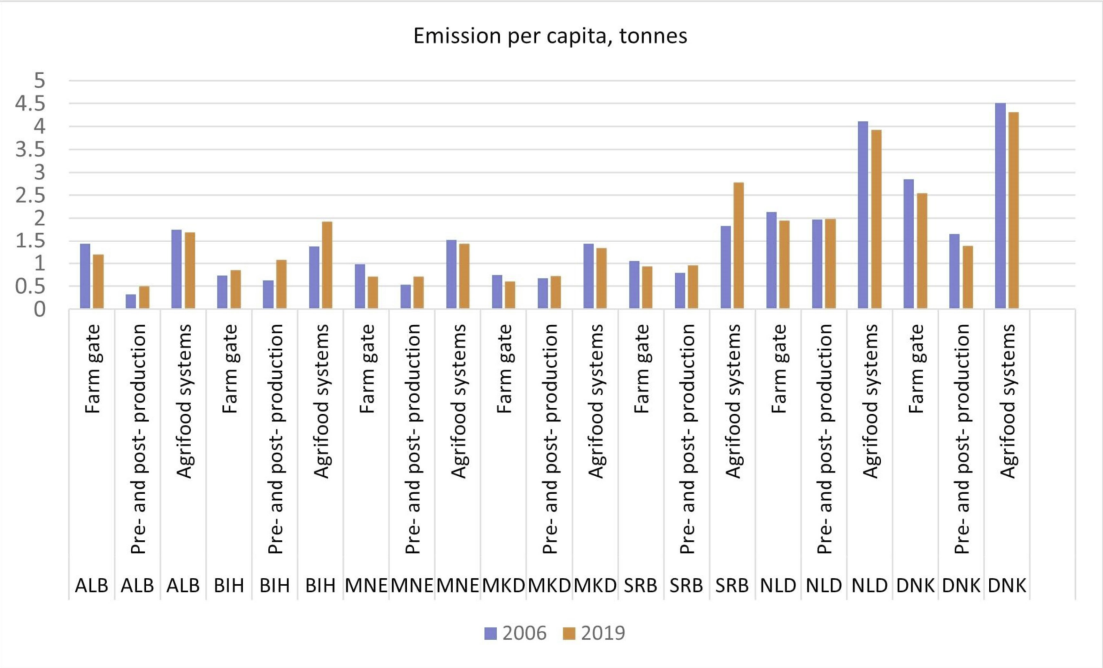

Figure 1. Agri-food systems emissions by country (Source: The author's calculations)

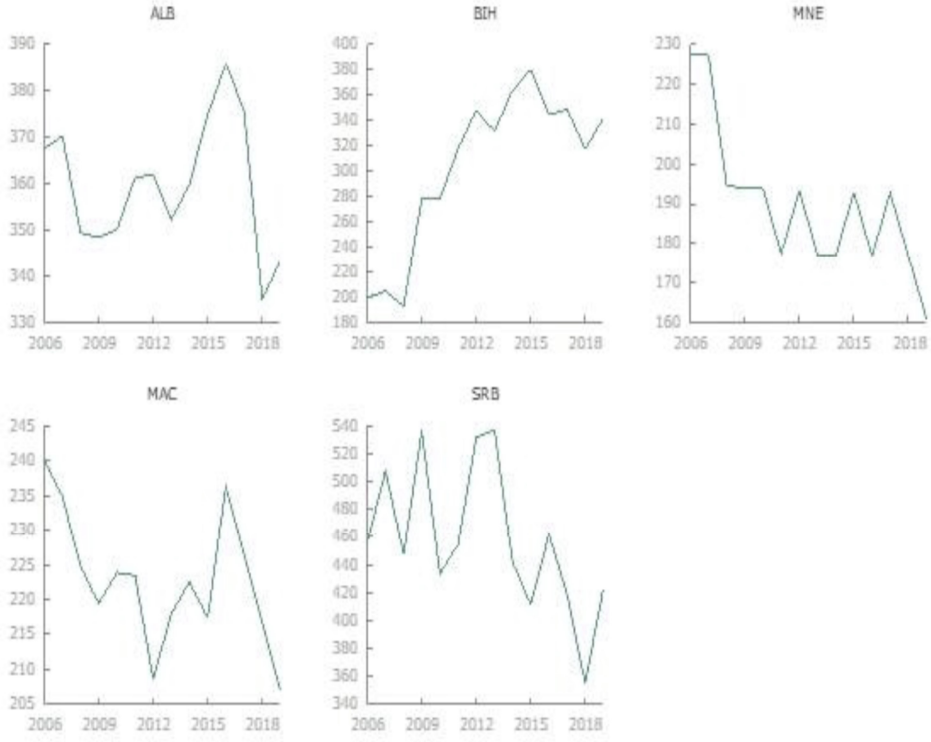

Figure 2. Agricultural nitrous oxide emissions per capita, kg CO_2-eq (Source: The author's calculations)

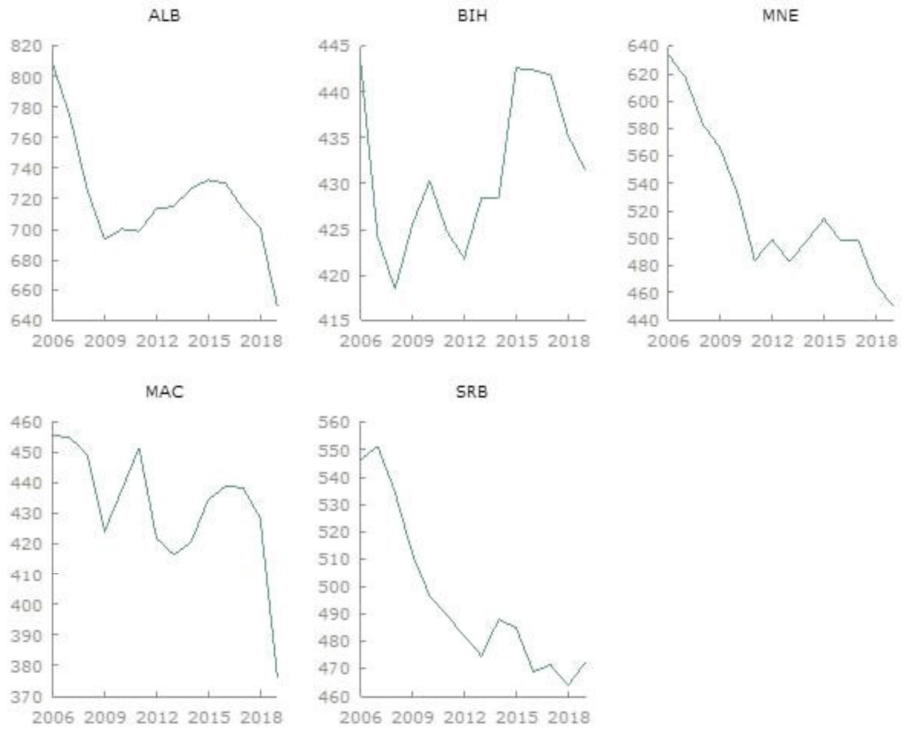

Figure 3. Agricultural methane emissions per capita, kg CO_2-eq (Source: The author's calculations)

methane emissions per capita in Denmark was 765.2 and 1084.7 kg CO_2-eq, respectively (World Bank, 2023).

Descriptive statistics that confirmed significant differences in agricultural emissions and in other variables among Western Balkan countries are shown in Table 2.

After conducting adequate panel diagnosis tests (Joint significance of differing group means, Breusch-Pagan, and Hausman test statistic), it was found that our models suffer from heteroskedasticity and autocorrelation, so we rejected fixed and random-effect panel models as a solution for the analyses of nitrous oxide and methane emissions. As the most appropriate model to have efficient estimators, we performed the Weighted Least Squares method (WLS) (Tables 3 and 4).

We were not able to find significant influence of economic development (proxied by the GDP per capita) on agricultural (nitrous oxide and methane) emissions. A widely accepted position in theory that affluence enhances production and boosts demand for foods cannot be applied to Western Balkans, a region in critical demographic decline (Lukic et al., 2012). According to our study agriculture's value added had a negative and significant effect on nitrous oxide emissions but a positive and significant effect on methane emissions. These findings are partially in line with our expectations and could be explained by the assertion that agriculture value added had a negative effect on emissions to a certain critical threshold where it become harmful to the environment (Raihan, 2023). Furthermore, it implies that the factors of

Table 2. Descriptive statistics

Variable	Mean	Median	S.D.	Min	Max
x	0.000307	0.000325	0.000104	0.000161	0.000537
y	0.000520	0.000478	0.000112	0.000376	0.000809
GDP	4.91e+003	4.83e+003	1.07e+003	2.85e+003	7.68e+003
A	9.76	7.79	4.57	5.60	20.0
FDI	7.74	6.52	6.11	0.536	37.3
T	94.9	92.4	17.1	66.0	139.
E	2.75e+003	1.22e+003	2.82e+003	248.	1.21e+004

Source: The author's calculations

Table 3. Estimation of nitrous oxide emissions using WLS model

	Coefficient	Std. Error	t-ratio	p-value	
const	−8.02629	0.771397	−10.40	<0.0001	***
GDP	−0.0140614	0.0773435	−0.1818	0.8563	
A	−0.131181	0.0406833	−3.224	0.0020	***
FDI	−0.00334006	0.0154614	−0.2160	0.8297	
T	−0.343954	0.0845044	−4.070	0.0001	***
E	0.252129	0.0130930	19.26	<0.0001	***
Statistics based on the weighted data					
Sum squared resid	61.49258	S.E. of regression		0.980215	
R-squared	0.936983	Adjusted R-squared		0.932060	
F(5, 64)	190.3203	P-value(F)		5.02e-37	
Log-likelihood	−94.79044	Akaike criterion		201.5809	
Schwarz criterion	215.0719	Hannan-Quinn		206.9397	
Statistics based on the original data					
Mean dependent var	−8.146065	S.D. dependent var		0.342318	
Sum squared resid	1.193403	S.E. of regression		0.136554	

Note: *, ** and *** level of significance 10%, 5% and 1%, respectively. Source: The author's calculations

Table 4. Estimation of methane emissions using WLS model

	Coefficient	Std. Error	t-ratio	p-value	
const	−8.38931	0.617104	−13.59	<0.0001	***
GDP	0.0874128	0.0758215	1.153	0.2532	
A	0.326460	0.0368456	8.860	<0.0001	***
FDI	0.0879221	0.0154620	5.686	<0.0001	***
T	0.0281447	0.00908899	3.097	0.0029	***
E	−0.224000	0.0707044	−3.168	0.0024	***
Statistics based on the weighted data					
Sum squared resid	68.66621	S.E. of regression		1.035813	
R-squared	0.803993	Adjusted R-squared		0.788680	
F(5, 64)	52.50369	P-value(F)		2.37e-21	
Log-likelihood	−98.65237	Akaike criterion		209.3047	
Schwarz criterion	222.7957	Hannan-Quinn		214.6635	
Statistics based on the original data					
Mean dependent var	−7.581187	S.D. dependent var		0.198260	
Sum squared resid	0.491829	S.E. of regression		0.087663	

Note: *, ** and *** level of significance 10%, 5% and 1%, respectively. Source: The author's calculations

agricultural emissions vary across time (Sadorsky, 2013). The positive impact of FDI inflows on agricultural (methane) emissions is inconsistent with our expectation and with evidence found in Seker et al. (2015). Our finding implies that multinational firms take advantage from locating production in Western Balkan countries where environmental norms are laxer. This supports the pollution haven hypothesis (Nguyen et al., 2020).

The last two explanatory variables - trade, and energy consumption had an expected significant influence on agricultural (nitrous and methane) emissions. Trade seems to have a significant and negative effect on agricultural emission. This finding consistent with evidence found in ten newly industrialized countries (Zhang et al., 2017) and Tunisia (Amri, 2018) highlights the importance of the green technologies' spillovers. Energy consumption as a proxy for the technological progress in emissions reduction had a positive and significant effect on agricultural emissions. Similar findings have been found in many research articles (e.g., Alkhathlan & Javid, 2013; Alam et al., 2016; Usman et al., 2019, etc.).

4. CONCLUSION

This paper investigated the relationship between agricultural nitrous oxide and methane emissions and different socio-economic determinants. The hypothesis of this research is partially confirmed, as one of the key assumptions that the influence of GDP per capita on agricultural emissions is significant and positive was unproven. The mixed results were obtained for agriculture value added and FDI. However, signed as expected, trade and energy consumption had a significant influence on both nitrous oxide and methane emissions.

For all Western Balkan's countries, it is valid that the GHG emissions lag significantly behind the level of the EU's developed countries. This finding has a double meaning. On one side, the region has no urgent need to reduce livestock to comply with the Green Agenda. On the other side, it is necessary to incorporate a sustainable approach to farming to combat the threat of climate change. The region has all the necessary resources for sustainable farming, including available land, which is particularly emphasized by demographic decline. In addition, attention should be given to the implementation of pollution-reducing technologies through FDI transfer in line with the pollution hallo hypothesis. In other words, environmental regulations in the region should be strengthened to prevent multinational companies from using technologies that have unfavourable effects on emissions.

Although this research can be seen as a pilot study of a complex phenomenon, its results put forward some recommendations for the consideration of policymakers.

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ФАКТОРИ КОЈИ УТИЧУ НА ПОЉОПРИВРЕДНУ ЕМИСИЈУ НА ЗАПАДНОМ БАЛКАНУ: ПАНЕЛ АНАЛИЗА ПОДАТАКА

Татјана Бранков

Извод

Смањење пољопривредне емисије једно је од најважнијих питања у глобалној политици, које постаје све изазовније како време одмиче. Да бисмо ово решили, наша студија истражује главне детерминанте пољопривредне емисије на Западном Балкану, узимајући у обзир бруто домаћи производ (БДП), додату вредност пољопривреде, трговину, употребу енергије у пољопривреди и стране директне инвестиције (СДИ). Емпиријски резултати засновани на анализи панел података показали су да БДП нема значајан утицај на емисију. Додата вредност пољопривреде имала је значајан и негативан утицај на емисију азот оксида и значајан и позитиван утицај на емисију метана. Трговина је значајно негативно утицала на емисије азот-оксида и метана, док је потрошња енергије имала значајан и позитиван утицај на емисије азот-оксида и метана. СДИ су имале значајан и позитиван утицај на емисију метана, док њихов утицај на емисију азот оксида није био статистички значајан. Овај чланак може послужити као основа за даља истраживања на ову тему.

Кључне речи: пољопривредна емисија, панел анализа података, Западни Балкан, азот, метан

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