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Original Research

Modeling the Dynamic Linkages between Agriculture, Electricity Consumption, Income and Pollutant Emissions for Southeastern Europe

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Abstract

This article investigated the short and long-run relationships between pollutant emissions, income, electricity consumption, and the value added by agriculture, forestry, and fishing by applying the agriculture-induced environmental Kuznets curve hypothesis to Southeastern Europe (SEE) countries from 1996 to 2016. The article's findings support the evidence of an agriculture-induced environmental Kuznets curve phenomenon in the long-run using the panel autoregressive distributed lag (ARDL) of the pooled mean group (PMG) and fully modified ordinary least square (FMOLS). The short-run findings evidence the legitimacy of an agriculture-induced environmental Kuznets curve phenomenon for Bosnia and Herzegovina, Croatia, Moldova, and Turkey. The bidirectional causality between pollutant emissions and electricity and pollutant emissions and agriculture is confirmed. Moreover, a unidirectional causality is found between income and pollutant emissions. Our results, by revealing the positive inelastic impact of agriculture on pollutant emissions, suggest that greater agricultural production increases electricity consumption and thus leads to higher carbon emissions in SEE countries, calling into dispute the sustainability of agriculture-driven growth.

Keywords: agriculture, electricity consumption, environmental Kuznets curve, Southeastern Europe

Introduction

The association between environmental quality and economic output is based on the pollutant emissions-income linkage adopted by environmental studies known as the environmental Kuznets curve (EKC) hypothesis after the pioneer manuscript by Grossman and Krueger [1]. The EKC phenomenon proposes that there exists an inverted U-shaped relationship between pollutant emissions and economic output (growth/income). This concept has attracted the attention of the academic world [2-13] and argues that, in the first stage of economic emancipation, environmental damage

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increases as income increases, while environmental degradation starts to dwindle in the latter stages of growth. In other words, the EKC phenomenon suggests that economic growth will irrevocably disentangle and/or reconsider the unfavorable environmental effect triggered in the first stage of economic growth.

To verify the authenticity of the EKC hypothesis, the traditional model has gradually been phased out to augment agriculture [4, 9]. Agriculture is an essential segment of any economy and an important tool for developing countries since it plays a key role in the growth process. Moreover, this sector increases the total productivity of the economy and competitiveness. This segment plays a unique role in poverty reduction. Agriculture offers raw materials to industry, supplies food and contributes to international trade. Unlike the positive externalities, agriculture has negative impacts on the environment. Farming and chemical fertilizers can damage the soil, reduce the water quality and increase carbon emissions due to intensive energy consumption. Given the importance of the agricultural sector and its linkage with the income-pollutant emissions nexus, our study augments the EKC theory by incorporating agriculture into what we call the agriculture-induced EKC hypothesis.

Agriculture-induced EKC hypothesis was tested in the case of China for the period of 1971-2014 [4]. The ARDL estimation results evidenced the legitimacy of agriculture-induced EKC hypothesis. Authors emphasize that Chinese government should develop strategies to enhance the development of clean technologies in agricultural sector and transportation that will significantly reduce the pollutant emissions. Similarly, the case study of Argentina is used to evaluate the validity of EKC hypothesis in the period of 1970-2012 [5]. The study reports dynamic relationship between income, agriculture and methane emissions. Agriculture, however, demonstrates significant negative impact on methane emissions. The long-run association between pollutant emissions, renewable and non-renewable energy, agriculture and economic growth was examined for a panel of E7 countries [7]. The article findings report significant positive impact of economic growth, non-renewable energy and agriculture on pollutant emissions but negative impact of squared economic growth and renewable energy. Recent studies [8-14] show that income, energy consumption and agriculture are important determinants of environmental degradation. However, the empirical research findings vary and fail to clarify the background and policy implications. Such research findings may be inferred from the fact that the previous literature used different model specifications, data samples and estimation techniques. Besides, no study analyzes the relationship of interest considering the case of SEE countries. In addition, a specific analysis of electricity as a special form of energy use has not been taken into consideration. Considering the abovementioned, our research aims to fill the gap within the context of SEE countries with a special focus on the environmental impact of electricity consumption. All in all, the research on the agriculture-induced EKC hypothesis can help to unveil whether or not the agricultural sector reduces environmental depletion and offer as important insight for policy makers in SEE countries.

The strong growth in the economic activity of Southeastern Europe (SEE) in recent years has been mostly due to the relatively large economies that are strategically located on some of the main transport routes to Western Europe. Despite this strong growth in the SEE countries, the economic recovery has not been sufficient to compensate for the deep economic problems caused by the breakup of the former Yugoslavia.

The SEE countries rank among the worst in Europe for air pollution arising from severe challenges related to plastic, air and water pollution. Despite the serious environmental threats, the economic and environmental reasoning behind the region's energy plan includes building new coal power plants, which was the rationale for the author selecting ten SEE countries as the sample for this study. Accordingly, the expectation is that the environmental Kuznets curve (EKC) hypothesis will be verified by the SEE countries and these countries seem to be noteworthy, representative countries for examining the legitimacy of the EKC phenomenon. The motivation behind selecting SEE countries can be summarized as: (i) these countries share a common recent history of conflicts and instability; (ii) these countries share high quality environmental and natural resources; (iii) common issues related to the anthropogenic emissions; (iv) despite significant international support, the results in terms of actual pollution reduction are still limited.

The purpose of this study is to investigate the legitimacy of the agriculture-induced EKC phenomenon. The primary objective is to unearth the long-run relationship between pollutant emissions, economic growth, electricity consumption and agriculture. Determining the long-run relationship can contribute to sustainable development. Second, the exploration of the causal linkage between the inspected variables can contribute to the information content about agriculture and other variables with regard to environmental damage [7, 15]. The research hypothesis of our study investigates the legitimacy of the agriculture-induced EKC theory in the authors' sample countries. Hence, if the agriculture-induced EKC theory is confirmed, then one can clearly anticipate an inverted U-shaped relationship between growth and pollutant emissions, while the rejection of the agriculture-induced EKC theory suggests that, in the later stages of economic emancipation, the amount of environmental damage will increase.

Our study makes an original contribution to the existing literature by examining, in the light of updated data, the significant indicators of pollutant emissions using the agriculture-induced EKC theory. To the best of our knowledge, the studies conducted to date have neglected the impact of agriculture within the context of SEE economies. This study goes slightly further by undertaking a specific analysis of electricity as a special form of energy use. Equally importantly, we employ a panel VECM framework to reveal the short- and long-run causal relations among the variables.

This study is divided into four sections. Section 2 explains the proposed model and methodology. Section 3 outlines and discusses the main findings. The conclusion and policy implications are presented in Section 4.

In the light of the existing literature, we consider balanced panel data on ten Southeastern Europe countries for the period 1996-2016 to examine the legitimacy of the agriculture-induced EKC theory. The SEE region includes 13 countries [16]. Data about the inspected variables were available for: Albania, Bulgaria, Bosnia and Herzegovina, Greece, Croatia, Moldova, North Macedonia, Romania, Slovenia, and Turkey, so our study focuses on these ten countries and does not inspect the cases of Serbia, Montenegro and Kosovo.

Material and Methods

In this research, annual panel data spanning over 1996 to 2016 are compiled for the ten SEE countries to investigate the authenticity of agriculture-induced EKC phenomenon. The authors will apply a cross-sectional dependence test preceding further analysis. In order to encounter the stationary properties of the variables, we use conventional panel data techniques. The dynamic relationship and causal link in our study were investigated by examining five variables. The data about carbon emissions (CO_2 emissions, metric tons per capita), the income per capita (GDP per capita, constant 2010 US$), the squared income per capita and agriculture (agriculture, forestry, and fishing, value added, % of GDP) were acquired from the World Bank Development Indicators Database 2020 release [17] whilst the data for the electric power consumption (kWh per capita) were acquired from the World Bank and the International Energy Agency [17, 18].

Economic growth and electricity consumption represent two dominant contributions to environmental degradation. Given that we are interested in the short- and long-term impact of the selected variables in light of the agriculture-induced EKC hypothesis, we propose the following agriculture-based model for a panel of ten SEE countries (Eq. 1):

$$CAE = f(PEO, PEO^2, CEP, AFF) \quad (1)$$

where CAE refers to the indicator of pollutant emissions, PEO and PEO^2 capture the income per capita and squared income per capita respectively, CEP captures the type of energy consumption i.e. electricity, and AFF corresponds to the proxy of agricultural sector. The long-run relationship comprising pollutant emissions, electricity consumption and income is formulated by a linearly developed logarithmic structure [4, 9, 19-21] with consideration of the agriculture-induced EKC theory in the following equation (Eq. 2):

$$L(CAE)_{it} = \alpha_0 + \alpha_1 L(PEO)_{it} + \alpha_2 L(PEO)^2{}_{it} + \alpha_3 L(CEP)_{it} + \alpha_4 L(AFF)_{it} + \varepsilon_{it} \quad (2)$$

Here, i captures a specific country in the sample of ten SEE economies, t stands for a time period between 1996 and 2016, ε_{it} refers to the residual term and α_0 corresponds to the constant. Moreover, $\alpha_1 - \alpha_4$ capture the long-term coefficients of the income, squared income, electricity consumption and agricultural sector. The estimable regression Eq. (2) is represented by a logarithmic structure, where L corresponds to a natural logarithm.

Following the recent empirical literature [22-26], carbon dioxide emissions (metric tons per capita) are used as a proxy to illustrate the pollutant emissions for a panel of SEE countries. It has been specified that the first stage of economic emancipation results in environmental damage due to the high pressure on the environment. Since income has a predictive capacity regarding pollutant emissions in the following recent studies [27-30], our research introduces per capita GDP in constant 2010 USD as a proxy for income. To test whether or not, as income increases, environmental degradation starts to dwindle, this research introduces the squared income under the EKC hypothesis. It is astonishing that the research on the dynamic relationship between pollutant emissions and electricity consumption is sporadic and insufficient; accordingly, this study introduces electric power consumption (kWh per capita) as a proxy for electricity use, which is strongly justified in the empirical literature [31-33]. Pollutant emissions are predominantly influenced by electricity use, due to the important role of other emitting sectors, among which industry and transportation are the leading sectors. Agricultural development supports the economy as a whole by improving competitiveness, promoting international trade and supplying food and raw materials. Despite the positive externalities, the agricultural sector may potentially have negative environmental effects, which guided us to introduce agriculture, forestry, and fishing, and value added (% GDP) as a proxy for the agricultural sector in the present study, in line with [4, 8, 9, 34].

The legitimacy of the inverted U-shaped relationship depends on the coefficients α_1 and α_2. Under the EKC hypothesis, α_1 is expected to be positive and α_2 is expected to be negative. In the case where these two coefficients equal zero, there is no clear evidence on the pollutant emissions-income nexus. A positive linear relationship will be displayed if $\alpha_1>0$; $\alpha_2 = 0$ and a negative one if $\alpha_1>0$; $\alpha_2 = 0$. Finally, the relationship between pollutant emissions and income will be characterized as U-shaped if $\alpha_1<0$; $\alpha_2>0$.

In this study, the testing procedure consists of five steps. The cross-sectional dependence test [35] is used initially to test whether all of the units in the same cross-section are correlated. Prior to modeling the data, we check whether the order of integration is equal for all series. The panel unit root tests are performed in two parts. The Im-Pesaran-Shin test [36] and Phillips-Perron-Fisher Chi-square (PPF) [37] are used in the first part, whereas the second part includes the cross-sectionally augmented Im-Pesaran-Shin (CIPS) [38]. Under the null hypothesis, all statistics test the assumption of a unit root in the panel.

For the series that are integrated with the same order, we applied panel cointegration techniques [39, 40] to investigate the long-run association among the inspected variables. Under the null hypothesis, all statistics test the assumption of no cointegration. Westerlund [40] developed four panel cointegration test statistics that are robust to cross-sectional dependence and based on the error correction model (ECM).

Having acknowledged the presence of the long-run associations among the variables, the next step was to catch up for the sign of the coefficients with the independent variables. In other words, a panel autoregressive distributed lag (ARDL) model with a pooled mean group (PMG) and fully modified ordinary least squares (FMOLS) estimators for the panel cointegration regression were used to identify whether income, squared income, electricity consumption and agriculture have a positive or negative long-term association with pollutant emissions. The FMOLS estimators not only highlight the consistent estimates of the α parameters in Eq. (2), but also control for endogeneity and autocorrelations. In order to check the extent of the panel relationship among the competing variables, the FMOLS model is described as Eq. (3) [41]:

$$\beta_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}X_{it}'\right]^{-1}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}\bar{y}_{it}^{+} - \gamma_{12}^{+\prime}\right) \quad (3)$$

Here, the cointegrated variables are denoted by X_{it} and y_{it}. $\bar{y}^{+}_{it}$ captures the transformation of predictor variable and the corrected serial correlation terms (*i.e.*$\bar{y}^{+}_{it} = (y_{it} - \bar{y}_i) - \hat{w}_{12}\,\omega_{22}^{-1}\nabla_{22}$, where ω and ∇ are the estimates of long-run covariances; $\bar{\gamma}^{+\prime}_{12} = r_{12} - \hat{w}_{12}\,\omega_{22}^{-1}\Delta_{22}$. For further explanation of the estimation procedure please see [41].

The pooled mean group (PMG) that allows for a higher degree of parameter heterogeneity is sufficiently flexible to allow for long-run coefficient homogeneity. It assumes the IID error terms and exogeneity of the competing variables. A PMG estimator based on the *ARDL*(p, q, ..., q) model is developed as Eq. (4) [42]:

$$L(CAE)_{it} = \sum_{j=1}^{p}\theta_{ij}L(CAE)_{it-j} + \sum_{j=0}^{q}\rho_{ij}x_{it-j} + \mu_i + u_{it} \quad (4)$$

Here, x_{it} captures the explanatory variables $L(PEO)$, $L(PEO^2)$, $L(CEF)$ and $L(AFF)$, ρ_{ij} stands for the vector of the regression parameters θ_{ij} is the regression parameter with a lagged dependent variable, μ_{ij} is the fixed effects, and u_{it} is the general disturbance term. The short-run model can be shown as the empirical structure (Eq. 5):

$$\Delta L(CAE)_{it} = \alpha_0 + \sum_{i=1}^{p}\theta_i\Delta L(CAE)_{t-i} + \sum_{j=1}^{q}\delta_j\Delta L(PEO)_{t-j} + \sum_{m=1}^{q}\beta_m\Delta L(PEO^2)_{t-m} + \sum_{r=1}^{q}\varphi_r\Delta L(CEP)_{t-r} + \sum_{s=1}^{q}\sigma_s\Delta L(AFF)_{t-s} + \tau ECT_{t-1} + \varepsilon_{it} \quad (5)$$

Where the lag lengths are captured by q and *ECT* stands for the error-correction term.

Even if the cointegration techniques evidenced the long-run association among the inspected variables, these techniques do not give the direction of causality. Granger causality tests based on the vector error correction model (VECM) are imperative to evaluate the direction of the short- and long-term causality which may comprise pollutant emissions, income, electricity consumption and agriculture. The variable x is said to Granger cause y if the past value of x helps to predict the present value y. In other words, the Granger causality tests provide solutions in relation to whether x causes y and/or y causes x. It permits the detection of both the short- and long-term causalities. The short-run causalities are tested with a Wald test while the long-run causalities are examined by the t-statistics of ECT.

Results and Discussion

Before testing the stationary properties of the inspected variables, this study conducts a cross-sectional dependence test [35] to detect any potential correlation among the cross-sections. The null hypothesis (H_0) on the existence of cross-sectional independence is rejected claiming the cross-sectional dependence issue. Table 1 displays the analysis that was undertaken to investigate the stationary properties of the variables. We consider two cases: (1) the intercept appeared explicitly and (2) both the intercept and the trend appeared explicitly.

The Im-Pesaran-Shin test [36] demonstrates that the series, namely the proxy for pollutant emissions, income, income squared and electricity consumption, are non-stationary at level in both cases (the intercept appeared explicitly and both the intercept and the trend appeared explicitly). The Phillips-Perron-Fisher Chi-square (PPF) shows that the series, namely income, income squared and electricity consumption, are non-stationary at level in both cases (the intercept appeared explicitly and both the intercept and the trend appeared explicitly). However, the proxy for agricultural sector does not have a unit root in either the IPS or PPF test. Table 1

Table 1. Stationarity Tests Results.

Variables	Test	Levels		First differences	
		Intercept	Intercept and trend	Intercept	Intercept and trend
L(CAE)	IPS	0.76	-0.50	-6.64***	-5.96***
	PPF	44.76***	42.89***	147.16***	119.60***
	CIPS	-1.84	-3.37***	-4.44***	-4.69***
L(PEO)	IPS	0.26	0.39	-3.26***	-1.83**
	PPF	22.46	27.06	100.75***	83.88***
	CIPS	-2.91***	-3.12***	-4.11***	-4.34***
$L(PEO)^2$	IPS	0.58	0.38	-3.25***	-1.73**
	PPF	20.85	25.84	98.89***	81.03***
	CIPS	-2.86***	-3.11***	-4.10***	-4.35***
L(CEP)	IPS	0.19	-0.66	-5.18***	-3.34***
	PPF	24.70	26.87	109.67***	80.84***
	CIPS	-2.05	-2.41	-3.87***	-3.69***
L(AFF)	IPS	-1.44*	0.52	-4.68***	-3.63***
	PPF	43.47***	38.17***	194.05***	133.46***
	CIPS	-2.61***	-3.47***	-4.70***	-4.82***

Note: Significance levels: *p<10%, **p<5%, ***p<1%.
Source: [17, 18]; authors'calculations.

clearly shows that the *CAE*, *PEO*, *PEO*^{2}, *CEP* series have a unit root at level but become stationary at their first difference. Given the cross-sectional dependence (CIPS) test results, none of the series evidenced a panel unit root at their first difference, meaning that they are integrated at order I(1).

Having acknowledged that all series are I(1), the Johansen-Fisher and Westerlund cointegration tests [39, 40] were used to identify the possible correlations among pollutant emissions, income, income squared, electricity consumption and agriculture in the long-run. The trace test depicts the number of cointegration vectors. Table 2 clarifies the presence of a long-term linkage among the observed variables. In other words, the null hypothesis that there exist a maximum of four cointegration equations is not rejected. In this regard, the Johansen-Fisher test outcomes are also supported by performing Westerlund [40] cointegration tests. Given the findings in Table 2, the majority of the tests (Gt, Pt, Pa) reject the null hypothesis that no cointegration exists. Hence, it can be justified that the Westerlund cointegration test is in line with the Johansen-Fisher cointegration test by validating the presence of a long-run linkage among pollutant emissions, income, income squared, electricity consumption and agriculture within the context of the agriculture-induced EKC phenomenon.

Table 2. Maddala and Wu (1999) and Westerlund (2007) Cointegration Tests.

Test	Statistic	Value
Maddala and Wu (1999)	Fisher (from trace test)	323.300***
		165.200***
		75.230***
		40.820**
		35.970
Westerlund (2007)	Gt	-2.873*
	Ga	-1.876
	Pt	-11.243***
	Pa	-10.290**

Note: Significance levels: *p<10%, **p<5%, ***p<1%.
Source: [17, 18]; authors'calculations.

Based on the evidence of a long-run linkage among the observed variables, it is necessary to estimate the long-run relationship using the FMOLS and PMG. Table 3 indicates the long-term elasticities of pollutant emissions, income, income squared, electricity consumption and agriculture.

Table 3 reports a positive relationship between pollutant emissions and income, electricity consumption and the agricultural sector. The statistically significant regression coefficient with both income and income squared along with the positive indicator with income and negative indicator with income squared are

Table 3. Elasticities using the FMOLS and PMG.

Estimation method/Variables	FMOLS Pooled	PMG Long-run	PMG Short-run	EKC
L(PEO)	3.114*** (0.951)	2.238*** (1.028)	Albania	No
L(PEO^2)	-0.176*** (0.058)	-0.184*** (0.033)	Bulgaria	No
L(CEP)	0.666*** (0.124)	0.567*** (0.088)	Bosnia and Herzegovina	Yes
L(AFF)	0.161* (0.090)	0.094*** (0.028)	Greece	No
ECT_{-1}		-0.252**(0.108)	Croatia	Yes
Groups	10	10	Moldova	Yes
Observations	200	190	North Macedonia	No
R-squared	0.946		Romania	No
Sum squared resid	3.757	0.397	Slovenia	No
Log likelihood		358.794	Turkey	Yes

Note: Standard errors in parentheses. Significance levels: *p<10%, **p<5%, ***p<1%. CAE is the dependent variable. ECT represents the error correction term.
Source: [17, 18]; authors'calculations.

accomplished to establish and document the inverted U-shaped association, thereby confirming essence of the agriculture-induced EKC hypothesis in the long-run. The pooled FMOLS shows that the elasticity of the proxy for pollutant emissions with regard to income is 3.114. This means that a 1% increase in income results in a 3.114% increase in carbon emissions. Similarly, the elasticity of the proxy for pollutant emissions with regard to squared income (-0.176) indicates that a 1% increase in squared income reduces carbon emissions by 0.176%. Regarding electricity consumption, a 1% increase in electricity use increases environmental degradation by 0.666% whilst a 1% increase in the agricultural sector increases environmental degradation by 0.161%.

In this respect, the FMOLS outcomes are also supported by the PMG estimator. Table 3 also reports that income, electricity consumption and the agricultural sector have a statistically significant positive impact on environmental degradation but the coefficient with income squared is significantly negative in the long-run via PMG. The highly significant ECT supports the stable, long-term association between the selected variables. It demonstrates, in fact, how fast the series converge to equilibrium. Given the statistically significant negative coefficient with ECT in Table 3, it can be concluded that environmental degradation restores equilibrium in Eq. (2).

Given that the outcomes of the pooled FMOLS and PMG techniques support consistent findings in terms of sign, magnitude and significance, these outcomes are marked as robust and steady for inference. Thus, the outcome that an inverted U-shaped relationship holds in the long-run is consistent with previous studies [2, 6-9]. Hence, the research hypothesis in our study cannot be rejected. With the economic development resulting in an ongoing increase in income, the negative consequences of a consumer society, with rapid urbanization, the increasing ownership of obsolete, second-hand cars imported from Western Europe and the rapid increase in the consumption of packaged goods are also becoming visible. Nevertheless, the policy-makers have tended to assume that the process of transportation and subsequent compliance with the EU Acquis Communautaire will automatically achieve environmental improvement. Moreover, the public seems to have accepted increasing pollution as a necessary by-product of progress [43]. In addition, the region strongly relies on fossil fuels for its energy/electricity consumption, so the positive coefficient with electricity consumption in Table 3 is to be expected and is consistent with the-state-of-the-art findings of [2, 6].

Efforts have been made by both governments and non-governmental organizations to raise environmental awareness, so the public in SEE countries is widely aware of the importance of natural resources. Nevertheless, people have trouble implementing more sustainable behavior due to the lack of adequate services (e.g. incomplete waste collection and a lack of recycling facilities) or financial resources. The lack of public services is sometimes also quoted as an excuse for harmful practices, such as dropping litter [43]. The number of environmental non-governmental organizations has been growing in the region since the mid-nineties, some started by concerned scientists and others by young, internationally-educated environmental professionals. These organizations mainly depend on international funding, so many have been more oriented towards implementing environmental projects than engaging in advocacy. The non-governmental organizations have significantly contributed to the capacity-building, policy development and awareness.

Table 4. Granger Causality Tests Within the VECM Technique.

Dependent variables	Short-run coefficients					Long-run coefficients
	ΔL(CAE)	ΔL(PEO)	ΔL(PEO^2)	ΔL(CEP)	ΔL(AFF)	ECT
ΔL(CAE)	-	0.101*** (-0.046)	1.536* (-0.819)	0.308*** (-0.091)	0.211* (-0.154)	-0.531 [-7.633]***
ΔL(PEO)	0.164 (0.112)	-	-15.454 (-14.311)	0.093 (-1.584)	-2.242 (-2.699)	-0.129 [-3.437]***
ΔL(PEO^2)	-0.021 (0.082)	0.042 (-0.044)	-	-0.017 (-0.088)	0.099 (-0.151)	-2.010 [-2.959]**
ΔL(CEP)	0.304*** (0.072)	0.030 (-0.039)	0.458 (-0.699)	-	-0.031 (-0.132)	-0.474 [-6.302]***
ΔL(AFF)	-0.098** (0.041)	-0.057*** (-0.022)	-1.004** (-0.399)	-0.046 (-0.044)	-	0.075 [0.588]
Observations	170					
R-squared	0.592	0.290	0.267	0.553	0.512	
S.E. of regression	0.068	0.037	0.665	0.074	0.125	
F-statistic	20.857	5.871	5.226	17.791	15.062	
Log likelihood	221.783	325.442	-165.579	208.546	117.987	

Note: Standard errors are presented in parentheses and tstatistics in brackets. ECT represents the error correction term. Significance levels: *p<10%, **p<5%, ***p<1%.
Source: [17, 18]; authors'calculations.

However, farming and chemical fertilizers are intensively used in the agricultural sector of SEE countries and significantly damage the soil, reduce the water quality and increase the carbon emissions due to the intensive energy consumption. Hence, the positive coefficient with agriculture is expected and in line with the findings of [3, 5, 7-9].

The PMG estimator assumes the homogeneity of the long-term parameters and allows short-term coefficients and error variances to be heterogenous across all SEE countries. In this context, our study employs the PMG estimator to explore the legitimacy of applying the agriculture-induced EKC hypothesis in the short-run. Country-based short-run analysis evidenced the validity of the agriculture-induced EKC phenomenon for Bosnia and Herzegovina, Croatia, Moldova and Turkey (Table 3). The agriculture-induced EKC phenomenon was not validated for Albania, Bulgaria, Greece, North Macedonia, Romania and Slovenia. The last decade of the 20th century witnessed a substantial drop in the economic output in SEE countries, which is in line with the fact that the inspected countries have always been among the least developed countries in Europe. Despite their rapid economic growth in the 21st century, most of the SEE countries today are relatively under-developed; they report the highest youth unemployment rates in Europe and face serious income disparities. These countries cope with the change of the nature of economic agents deteriorating the overall economic structure. These countries did not have an effective industrial policy and remain exceptionally agricultural in nature. As a result, the process of re-industrialization has been very slow, resulting in limited export growth and insufficient competitiveness. Agricultural and industrial advancements may subsequently bring about environmental challenges, as demonstrated by climate change as a consequence of carbon emissions. Herein, short-run period was not enough to achieve the positive environmental impact of the higher level of GDP per capita, rather a negative relationship between economic growth and environmental quality, but later, a positive relationship between economic growth and environmental quality is achieved only in the long-run.

Conclusively, our research uses the Granger causality test within the VECM technique to discover the short- and long-run causal relationships within the agriculture-induced EKC framework. Table 4 presents the findings (the voluminous output of the VECM estimation is available upon request).

As shown in Table 4, the Granger causality outcomes established a bidirectional causality between pollutant emissions and electricity in the short-run, which is in line with the survey results of [2, 9, 44, 45]. A two-way causal relationship is also reported between pollutant emissions and agriculture, which is similar to the research outcome of [4]. The result of the VECM demonstrates a one-way causality running from income to pollutant emissions, which is in line with [6, 8, 10]. Regarding the long-run Granger causality findings, income, squared income and electricity consumption are subject to convergence towards equilibrium.

Conclusions

Our study utilizes panel data econometric technique to examine the legitimacy of agriculture-induced EKC theory for ten SEE countries in the time-span of 1996-2016. After the initial analysis, we implemented the panel autoregressive distributed lag (ARDL) of the pooled mean group (PMG) and fully modified ordinary least square (FMOLS) to unearth the long-run parameters. Finally, the panel vector error correction model (VECM) and Granger causality test were proposed as vital approaches for analyzing the causal relationships between the variables.

The findings of this study support the validity of the agriculture-induced EKC phenomenon in the long-run. The country-based short-run analysis via PMG demonstrates the legitimacy of the agriculture-induced EKC phenomenon for Bosnia and Herzegovina, Croatia, Moldova and Turkey. The Granger causality test within the VECM technique reveals a bidirectional causality between pollutant emissions and electricity, pollutant emissions in the short-term. The result of the VECM also demonstrates a unidirectional causality spanning from income to pollutant emissions.

Regarding policy implications, this study verifies that SEE countries' long-run standpoint regarding economic activity is predominantly directed by different types of energy, primarily electricity. Nevertheless, the negative externalities that these types exert on the environment are harmful, as energy-related carbon emissions have increased significantly in the last few decades. Thus, policy-makers need to design more renewable energy policies that seek to promote the usage of cleaner energy sources. In the same vein, policy-makers need to develop policies and attract investors that will support energy efficiency. The adoption of a carbon tax might also serve to reduce the environmental degradation in SEE countries. The development of the agricultural sector should be accelerated to introduce biogas plants and wind or solar power stations to overcome the problems caused by energy-related carbon emissions due to heating and electricity use.

This study has certain limitations. Firstly, due to data availability it only considers the period 1996-2016 and ten SEE countries, so the comprehensiveness of our findings might be questioned. Secondly, our study does not observe combined data (e.g. total energy consumption) or separate data on different types of energy (e.g. thermal energy), focusing solely on separated data on electrical energy. As a final point, in addition to income, squared income, electricity consumption and the agricultural sector, the development of EKC should be accelerated by taking particular account of the role of the manufacturing sector and tourism.

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Conflict of Interest

The authors declare no conflict of interest.

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