THE RELATIONSHIP BETWEEN RENEWABLE ENERGY CONSUMPTION, TRADE OPENNESS AND ECONOMIC GROWTH: THE CASE OF BOSNIA AND HERZEGOVINA

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Abstract

The paper examines the renewable energy consumption-trade openness-economic growth nexus for Bosnia and Herzegovina using annual time series data covering the period of 1994-2015. The variables in the analysis were checked using Augmented Dickey Fuller test statistics. The results obtained indicated that economic growth became stationary at level while renewable energy consumption and trade openness variables became stationary at first difference. According to Todo-Yamamoto Causality Test results, there is a unidirectional causality from renewable energy consumption to economic growth at 5 % in the long run. This finding is in line with the growth theory which remarks unidirectional/one-way causality from renewable energy consumption to economic growth. In this case, renewable energy dependent conservation policy may have prohibitive effect on economic growth. The study also concluded that there is no association between trade openness and economic growth. Thus, the finding supports the neo-classical growth theory. Besides, there is a causality from renewable energy consumption to trade openness, so the conservation policies will affect the trade and trade liberalization policies designed to promote economic growth.

Keywords: renewable energy consumption, trade openness, economic growth, time series analysis, Bosnian economy

JEL: F10, F18, O44, Q20, Q43

1. Introduction

The production, which increased rapidly after the industrial revolution, brought about environmental degradation due to the fact that a large amount of fossil fuels was used as energy input. Although the main objective of the countries was to provide economic growth, environmental problems were ignored at the beginning. After the 1960s, global warming and consequently climate and environmental changes became an important problem, and this questioned the relationship between environmental pollution and economic growth. The consequences of growth in the context of environmental pollution and sustainability have made it a necessity for countries to switch to cleaner technologies in the production process. In this sense, although developed countries have started to transition to environmentally friendly production systems, especially since the 1990s, developing countries continued to increase their production at the expense of environmental degradation due to higher costs required by clean technologies (Artan *et al*., 2015, p. 309). Special policies are developed to further promote the expansion of renewable energy sources with the increasing importance of environment protection. In a global context of analysis, about 19 % of the total energy usage is produced from renewable energy sources, while the strategic planning is to increase their usage by 50 % by 2050 (Ntanos *et al*., 2018, p. 1). Trade openness also plays a crucial role in economic growth. On the one hand, achieving higher international trade volumes requires more energy. This requirement is not necessary only for production of goods but also for their transportation. On the other hand, eliminating the barriers generates new financial instruments. Diversification of financial instruments reveals financial development levels. Furthermore, urbanization level increases in export-oriented industrialization, moving population from agricultural sector to industrial and service sectors, especially

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in developing countries (İşgüven & Şeker, 2019, p. 154).

Bosnia and Herzegovina (BiH) is a small developing country with the population of roughly 3.8 million. BiH is in the process of creating a foundation for sustainable economic growth after a period of successful post-conflict recovery after the war of 1992-1995 (Nikolakakis, 2019, p. 47). The energy sector in BiH is characterized by high energy intensity when compared with developed EU countries, which is the key indicator of the impacts of energy utilization. BiH's total energy supply in 2007 was 5.6 Mtoe. Coal had the highest share in the total energy consumption (62.6%), while oil and oil products (22.7%), natural gas (6.2%) and renewable energy sources (9.4%) followed (Karakosta *et al*., 2012, pp. 5167-5168). As an EU membership candidate and a developing country, BiH's shift to renewable energy production and consumption is expected to affect BiH's economic activites, especially import and export indicators.

There exists a continuous research about the fulfillment of rapidly rising energy demand without damaging the environment. Some past studies in the literature (Dolecek & Karabegovic, 2013; Karakosta *et al*., 2012; Petrovic & Smajevic, 2005) all emphasized the importance of renewable energy usage for sustainability, clean environment strategies and EU membership for BiH in the theoretical context. This study was designed to fulfill the gap in the available literature about the causality of renewable energy consumption, trade openness and economic growth of BiH. Despite its geographical richness, the use of renewable energy sources is restricted in BiH, just like in other Balkan countries. Thus, this study also was designed to make an assessment through handling the issue from an economic perspective. Besides, it would be a guide for future studies in terms of seeing how renewable energy affects economic determinants such as economic growth and trade openness. The following section of the paper provides the literature for renewable energy consumption-economic growth nexus, trade openness-economic growth nexus and renewable energy consumption-trade openness nexus. Section 3 discusses the methodology including the sources of data, model specification, and tools of the analysis. Section 4 shows the empirical findings and discussion. Finally, Section 5 provides conclusions.

2. Literature review

2.1. Literature regarding renewable energy consumption-economic growth nexus

In the literature, there are four hypotheses regarding causality direction between renewable energy consumption and economic growth (Öztürk, 2010):

1) The growth hypothesis remarks unidirectional/one-way causality from renewable energy consumption to economic growth. In this case, renewable energy dependent conservation policy may have a prohibitive effect on economic growth.
2) The conservation hypothesis is in contrast to growth hypothesis. According to this hypothesis, there is unidirectional causality from economic growth to renewable energy consumption. Therefore, renewable energy-related conservation policy may have little or no impact on economic growth.
3) The feedback effect hypothesis suggests bidirectional causality between renewable energy consumption and economic growth.
4) The neutrality hypothesis suggests the absence of causality between renewable energy consumption and economic growth. Thus, implication of renewable energy conservation policy has an insignificant effect.

There are many studies in the empirical literature that have examined the causality relationship between renewable energy consumption and economic growth in confirming the four hypotheses above. Among them, Apergis and Payne (2010) examined the relationship between renewable energy consumption and economic growth for a panel of 20 OECD countries over the period 1985-2005. The Granger-causality results indicated a bidirectional causality between renewable energy consumption and economic growth, both in the short and long run. The results supported the feedback effect hypothesis. Menegaki (2011) analyzed the causal relationship between economic growth and renewable energy for 27 European countries in a multivariate panel framework over the period 1997-2007. The study conclu-

ded that there is no causality between growth and renewable energy, so it confirms the neutrality hypothesis. Bhattacharya (2016) investigated the impacts of renewable energy consumption on the economic growth of 38 top renewable energy-consuming countries for the period 1991-2012. They found that renewable energy consumption has a significant positive effect on the economic growth for 57 % of the selected countries. Thus, the findings support the growth hypothesis. Fotourehchi (2017) analyzed the long-run causality relationship between renewable energy consumption and economic growth during the period 1990-2012 for 42 developing countries. They found that there is a long-run positive unidirectional causality running from renewable energy to economic growth and confirmed the growth hypothesis. Marinaş et al. (2018) tested the correlation between economic growth and renewable energy consumption for ten EU countries from Central and Eastern Europe over the period 1990-2014, using the Auto Regressive and Distributed Lag (ARDL) modelling procedure. Their results showed that economic growth and renewable energy consumption dynamics are independent in Romania and Bulgaria, while there is a unidirectional causality from renewable energy consumption to economic growth in Hungary, Lithuania, and Slovenia. Thus, the neutrality hypothesis is valid for Romania and Bulgaria, while the growth hypothesis is valid for Hungary, Lithuania, and Slovenia in the study. Rahman and Velayutham (2020) explored the relationship between renewable and non-renewable energy consumption and economic growth for a panel of five South Asian countries over the period of 1990-2014. Dumitrescue-Hurlin panel causality test was used to see causal links between variables. The study revealed that there is a unidirectional causality running from economic growth to renewable energy consumption. Hence, this study supported the conservation hypothesis.

2.2. Literature regarding trade openness-economic growth nexus

The theoretical background on trade openness-economic growth nexus has its roots in the neo-classical theory of growth. The classical and neo-classical theorists strongly supported trade led growth hypothesis, and identified trade as engine of growth. Generally speaking, trade openness promotes growth since it enhances specialization and division of labor in production. The new growth theories emphasized trade policy framework which promotes effective resource allocation by reorienting factors into the sectors where the country enjoys comparative advantages in trade (see Solow, 1956; Helpman & Krugman, 1985; Romer, 1990; Edwards, 1992). The development of endogenous (new) growth theories offers a theoretical basis for empirical investigation of trade openness-economic growth nexus. In contrast, the neo-classical growth theory recognizes no association between trade openness and economic growth. It shows that economic growth is exogenously defined by technology (Hye & Lau, 2015: 189).

In the empirical literature, there are many studies on developing countries that examine trade openness-economic growth nexus. Among them, Yapraklı (2007) analyzed trade openness, financial openness and economic growth of Turkey by using multivariate cointegration analysis, error correction-augmented Granger causality tests and vector error correction model for the period of January 1990 to April 2006. According to the results, economic growth is positively affected by trade openness and negatively by financial openness in the long run. Nduka *et al*. (2013) compared the causal relationship between trade openness and economic growth in the pre and post Structural Adjustment Programme Periods in Nigeria. They applied Augmented-Dickey Fuller and Phillip-Perron tests for unit root and Engle-Granger approach for cointegration. The results of the cointegration test confirmed a long-run relationship between economic growth and trade openness. They also stated that an increasing level of openness will be beneficial for Nigerian economy. On the contrary, Musila and Yiheyis (2015) showed that there is a negative association between trade openness and economic growth, using annual time series data for Kenya. Fetahi-Vehapi *et al*. (2015) analyzed the effect of trade openness on economic growth of South East European countries (including BiH) over the period 1996 to 2012. Using the system GMM technique they found a positive and statistically significant growth effect of trade openness. Silajdzic and Mehic (2017) investigated the effect of trade

openness on economic growth in CEE countries over the period 1995-2013 by estimating Prais-Winsten-correlated panels using corrected standard errors (PSCE) method and dynamic least squares dummy variable (LSDVC) method. They found that trade openness has a positive effect on economic growth only in countries which make technology-intensive production. Uslu (2019) investigated the impact of trade openness and economic growth of Turkey by using time series analysis with multiple structural breaks for the period 1960-2017. According to the results of causality tests, there is no causality relationship in the short run between trade openness and the real GDP per capita while it exists in the long run.

2.3. Literature regarding renewable energy consumption-trade openness nexus

The third category of studies concerns those interested in the relationship between renewable energy consumption and trade openness. According to Sadorsky (2012), in theory there are many ways that energy consumption and inernational trade mutually affecteach other. An increase in exports means there is an economic activity and this will increase energy use. Also, a decrease in energy consumption will decrease the production of goods so it will have a negative impact on trade openness. Adversely, if international trade is found to Granger cause energy consumption or if there is no causality between energy consumption and international trade, conservation policies will not affect the trade and trade liberalization policies designed to promote economic growth.

Among empirical literature authors, Ben Aissa *et al*. (2014), used panel cointegration techniques to examine the relationship between renewable energy consumption, trade (exports and imports) and output in 11 African countries covering the period 1980-2008. They found no causality between output and renewable energy consumption and between trade and renewable energy consumption in the short run. Also, in the long run they found no causality running from output or trade to renewable energy. Aslan *et al*. (2017) investigated the relationship between energy consumption-economic growth and energy consumption-trade openness using the panel of G-8 countries over the period of 1980-2012. They found a unidirectional causality running from trade openness to energy consumption and from economic growth to energy consumption. Amri (2018) examined the linkage between both renewable and non-renewable energy consumption and trade for 72 countries over the period 1990-2012. The study revealed a bidirectional relationship between the two sorts of energy consumption and trade in both developed and developing countries in the sample. Recently, Zeren and Akkuş (2020) investigated the relationship between trade openness and renewable and non-renewable energy consumption for "Top Emerging Countries of Bloomberg" in the 1980-2015 period. The long-run relationship between panels is examined with Dumitrescu-Hurlin (2012) panel causality test, Westerlund (2006) panel cointegration test with multiple structural breaks, and Pesaran (2006) CCE-MG cointegration estimator. According to the findings, the use of non-renewable energy is one of main reasons for the increase in trade openness. In addition, the study concluded that an increase in renewable energy usage is an important factor in decreasing trade openness for these emerging countries. Although there are some studies covering the Balkan countries, the empirical literature review shows that there are not any specific studies regarding renewable energy consumption-economic growth, renewable energy consumption-trade openness and economic growth-trade openness relationships for BiH, which further justifies the significance of this study.

3. Data and methodology

The data was made up from annual time series data of renewable energy consumption, trade openness and the growth rate for BiH. The data ranges from 1994 to 2015. Due to comparability reasons, renewable energy consumption is presented as a percentage of the total final energy consumption of the country. Both trade openness (import + export) and economic growth data are presented in percentages of real GDP. Data of all variables are obtained from the World Bank Database. The logarithm of all series is taken in order to purify the series from small fluctuations and make them linear. Accordingly, LRENER denotes renewable ener-

gy consumption, LGRW denotes Growth Rate, and LTR stands for the trade openness.

Since the variables used in the econometric analysis are not stationary, there will be a regression fallacy problem, so it is necessary to examine the stationarity of the data before starting the analysis. Various unit root tests are used to study stationarity. ADF unit root test was used in the analysis. The test was carried out using constant (intercept) only and constant with trend in order to see how robust the outcome will be.

Toda-Yamamoto (1995) causality test (TY) was employed in the study so that the causality relationship between BiH's renewable energy consumption, economic growth and trade openness can produce a robust outcome. In the TY method, series can be included in the analysis without the need for information such as stationarity and cointegration, which can reduce the loss of information and observation (Göçer & Akın, 2016).

Due to the fact that some of the series are I (1) and some of them are I (0), the TY causality test method that allows the work with the level values of the series was preferred.

As the first step of the TY method, the lag length (k) suitable for the VAR model is determined. In the second stage, the integration level dmax of the variable with the highest degree of integration is added to the k lag length. In the third stage, the level values of the series and the VAR model are estimated for the lag (k + dmax). The three-variable VAR model to be estimated at this stage is given below:

$$LRENER_t = \alpha_0 + \sum_{i=1}^{k+d\,max} \alpha_{1i} LRENER_{t-1} + \sum_{i=1}^{k+d\,max} \alpha_{2i} LGRW_{t-1} + \sum_{i=1}^{k+d\,max} \alpha_{3i} LTR_{t-1} + \mu_t \quad (1)$$

$$LGRW_t = \beta_0 + \sum_{i=1}^{k+d\,max} \beta_{1i} LGRW_{t-1} + \sum_{i=1}^{k+d\,max} \beta_{2i} LRENER_{t-1} + \sum_{i=1}^{k+d\,max} \beta_{3i} LTR_{t-1} + \mu_t \quad (2)$$

$$LTR_t = \gamma_0 + \sum_{i=1}^{k+d\,max} \gamma_{1i} LTR_{t-1} + \sum_{i=1}^{k+d\,max} \gamma_{2i} LRENER_{t-1} + \sum_{i=1}^{k+d\,max} \beta_{3i} LGRW_{t-1} + \mu_t \quad (3)$$

Hypotheses are as follows:

H_{01}: Renewable energy consumption is not the cause of economic growth.
H_{02}: Economic growth is not the cause of renewable energy consumption.
H_{03}: Trade openness is not the cause of economic growth.
H_{04}: Economic growth is not the cause of trade openness.
H_{05}: Renewable energy consumption is not the cause of trade openness.
H_{06}: Trade openness is not the cause of renewable energy consumption.

4. Results and discussion

Table 1 explains descriptive statistics. It can be observed that average economic growth (LGRW) is 1.65 % with standard deviation of 1.20 % and maximum of 4.48 %.

Renewable energy consumption (LRENER) and trade openness (LTR) have a mean value of 3.10 % and 4.56 % respectively.

Probability value of LRENER, LGRW and LTR are greater than 0.05. This indicates the normal distribution of the variables. Distributions are slightly right-skewed. Kurtosis values of LRENER and LTR are slightly lower than 3. That means distribution is platykurtic. Kurtosis of LGRW is slightly greater than 3. That means distribution is leptokurtic. In brief, it can be interpreted that variables are distributed normally because all the kurtosis values are close to 3.

Table 1. *Descriptive statistics*

	LRENER	LGRW	LTR
Mean	3.106054	1.650535	4.564440
Median	3.001714	1.689172	4.553556
Maximum	3.731460	4.488074	4.833659
Minimum	2.649715	-0.356675	4.300681
Std. Dev.	0.330073	1.203792	0.130959
Skewness	0.448492	0.261637	0.234255
Kurtosis	2.114510	3.053886	2.710544
Jarque-Bera	1.456282	0.253660	0.278013
Probability	0.482806	0.880883	0.870222
Sum	68.33320	36.31177	100.4177
Sum Sq. Dev.	2.287907	30.43140	0.360153
Observations	22	22	22

Source: Computed by the author using E-views 10.0.

According to the result of ADF Unit Root Test, BiH's economic growth became stationary at level while renewable energy consumption and trade openness series became stationary at first difference.

the number of delayed terms included in the model (Gujarati & Porter, 2014, p. 655). For this purpose, the VAR model was established for three variables. At this juncture, all the five available lag length criteria (LR, FPE, AIC, SC, HQ) were used.

Table 2. *Results of ADF unit root test*

Unit Root Test	**Augmented Dickey-Fuller**			
Country	Variables	Level	1st Difference	2 nd Difference
Bosnia and Herzegovina	LRENER	-0.061004	-3.848609*	
	LGRW	-3.859431**		
	LTR	-2.997646	-6.977031*	
Bosnia and Herzegovina	LRENER	-0.061004	-3.848609*	

Note: Significance at 1 % is denoted by * and significance at 5 % is denoted by **.

Source: Computed by the author using E-views 10.0.

The precondition of the Johansen test is that all variables must be integrated in the same degree or all variables must not become stationary at the level. Thus, they are not adequate and sufficient for Johansen Cointegration Analysis. Due to the fact that the series of LRENER and LTR are I (1) and LGRW is I (0), the TY causality test method is suitable for this analysis.

Determining lagged values to be used in causality tests is an important problem. In order to make reliable relationships between variables and future predictions, appropriate delay values should be used in the analysis. Gujarati and Porter emphasized that the direction of causality is closely dependent on

Table 3 shows the appropriate lag lengths according to different information criteria.

Table 3. *The optimal lag selection criteria*

Lag	LR	FPE	AIC	SC	HQ
0	NA	0.001007	1.612219	1.760614	1.632680
1	31.11259*	0.000303	0.389891	0.983472*	0.471738
2	12.01221	0.000308	0.297872	1.336639	0.441104
3	9.215011	0.000355	0.145996	1.629949	0.350613
4	9.671488	0.000285*	-0.788302*	1.140837	-0.522299*

Note: **LR:** Likelihood Ratio Criterion, **FPE:** Final Prediction Error Criterion **AIC:** Akaike Information Criterion, **SC:** Schwarz Information Criterion, **HQ:** Hannan-Quinn Information Criterion

Source: Computed by the author using E-views 10.0.

Looking at the results in Table 3, it is evident that FPE, AIC and HQ information criteria give the lag length as 4. When the graphs of the model's error terms were analyzed, it was observed that SC and FPE's lag length recommendation as 1 eliminated the problem of autocorrelation. Therefore, it was appropriate to take the lag length of the model as 1.

Once the lagged coefficients of the VAR model were determined, the degree of maximum integration of variables (1) were added to the number of lags in the model. According to $k + d_{max} = 1+1=2$. Causality analysis was made within the framework of VAR model at 2nd degree.

Table 4. *AR roots table*

Lag Specification 1 2	
Root	Modulus
0.843676 - 0.353817i	0.914864
0.843676 + 0.353817i	0.914864
0.33072 – 0.429684i	0.430955
0.033072 + 0.429684i	0.430955
0.310773	0.310773
-0.276822	0.276822

Source: Computed by the author using E-views 10.0.

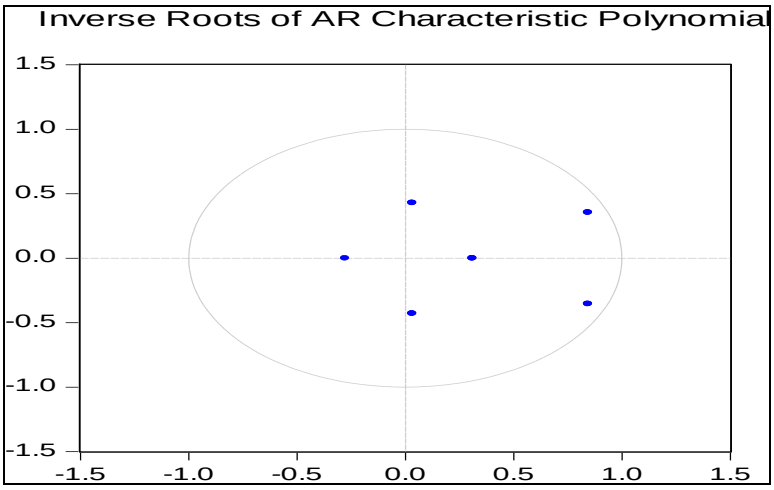

Figure1. *Inverse Roots of AR Characteristic Polynomial*

Source: Computed by the author using E-views 10.0.

Table and figure of the inverse roots of AR characteristic polynomial are shown in Table 4 and Figure 1 respectively. Results of Autocorrelation LM Test for BiH are shown in Table 5.

Because the maximum degree of integration of the series was 1 (*i.e.*, since the series is I(1) at most), k + dmax = 1 + 1 = 2 lagged regression models were estimated. Created VAR model was estimated via SUR (Seemingly Unrelated Regression). MWALD test was applied on p=2 lag and the results are presented in Table 6.

trade openness." hypothesis is accepted as well. The "H_0: Renewable energy consumption is not the cause of trade openness." hypothesis is rejected because probability is lower than 5 % level. In other words, renewable energy is the cause of trade openness.

Economic growth is not the cause of renewable energy consumption. The "Economic growth is not the cause of renewable energy consumption." hypothesis is accepted at 5 % level but is rejected at 10 %.

Table 5. *Autocorrelation LM Test Result*

Autocorrelation LM Test for BiH		
Lag	Prob.	LM Stat.
1	0.3268	1.200823
2	0.7927	0.589395
3	0.3598	1.145139
4	0.1001	1.837476

Source: Computed by the author using E-views 10.0.

Table 6. *Toda-Yamamoto Causality Test Results*

DEPENDENT VARIABLE: LGRW			
	X^2	df	Probability
LTR	0.682371	2	0.7109
LRENER	6.144869	2	0.0463
DEPENDENT VARIABLE: LTR			
	X^2	df	Probability
LGRW	0.234150	2	0.8895
LRENER	7.275446	2	0.0263
DEPENDENT VARIABLE: LRENER			
	X^2	df	Probability
LGRW	5.655054	2	0.0592
LTR	0.008145	2	0.9959

Source: Computed by the author using E-views 10.0.

According to TY causality test results, the "H_0: Renewable energy consumption is not the cause of economic growth." hypothesis is rejected because probability is lower than 5 % level. Renewable energy is the cause of economic growth.

The "H_0: Trade openness is not the cause of economic growth." hypothesis is accepted because probability is higher than 5 % level. The "H_0: Economic growth is not the cause of

Therefore, we can say there is a unidirectional relationship from renewable energy consumption to economic growth at 5 % for BiH.

Finally, the "H_0: Trade openness is not the cause of renewable energy consumption." hypothesis is accepted because probability is higher than 5 %. Thus, we can say there is unidirectional causality from renewable energy consumption to trade openness for BiH.

5. Conclusion

The study investigated the linkage between renewable energy consumption, economic growth and trade openness using an annual time series data of BiH for the period of 1994-2015. The relationship between renewable energy consumption, economic growth and trade openness was analyzed by employing the TY causality test in the study. More specifically, we have tried to fill the gap about the increasing importance of renewable energy sector and trade activities for BiH's economic growth.

The empirical findings revealed that there is a unidirectional causality from renewable energy consumption to economic growth at 5 % in the long run. This finding is in line with the growth theory which remarks a unidirectional/one-way causality from renewable energy consumption to economic growth. In this case, renewable energy dependent conservation policy may have prohibitive effect on economic growth. Therefore, to access the sustainable growth, Bosnian policy makers should avoid renewable energy dependent conservation policies and encourage the development of clean energy sector. To encourage the development of clean energy sector, they should introduce the appropriate incentive mechanisms and market accesibility of renewable energy. BiH's aspirations to join the EU compose a significant part of the authorizing environment for the energy sector.

According to the results of renewable energy consumption-trade openness nexus, the study concluded that renewable energy consumption has a statistically significant impact on trade openness. Therefore, conservation policies will affect the trade and trade liberalization policies designed to promote economic growth. The use of renewable energy may increase the production of goods so it would have a positive impact on trade openness through export activities. Although there is a unidirectional causality from renewable energy consumption to trade openness for BiH, we think that an indirect effect may exist probably in the long term, from trade openness to renewable energy consumption through technology transfer. Indeed, international trade helps the transfer of technologies, but a relatively long time is needed for BiH to build the necessary human and physical capacities for producing renewable energy. Renewable energy requires costly technology and infrastructure expenses of renewable energy plants are very high. This causes the usage of coal (62% of the total energy consumption) to be very common in BiH.

The findings also support the neo-classical growth theory, which does not recognize an association between trade openness and economic growth. It shows that economic growth is exogenously defined by technology. In this respect, this study does not support Fetahi-Vehapi's (2015) study regarding the results of trade openness-economic growth nexus for the Balkan countries including BiH. According to Silajdzic and Mehic's study (2017) on transition economies, trade openness has a positive effect on economic growth only in countries which make technology-intensive production. Thus, the findings suggest that if BiH as a transition economy produces and exports its technology-intensive products, it may increase its GDP this way.

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