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The renewable energy and economic growth nexus in Black Sea and Balkan countries

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ABSTRACT

The aim of this study is to explore the relationship between renewable energy consumption and economic growth within the framework of traditional production function for the period of 1990–2012 in 9 Black Sea and Balkan countries. For this purpose, we use Pedroni (1999, 2004) panel cointegration, Pedroni (2000, 2001) co-integration estimate methods and Dumitrescu and Hurlin (2012) heterogeneous panel causality estimation techniques. The study has concluded that there is a long term balance relationship between renewable energy consumption and economic growth and renewable energy consumption has a positive impact on economic growth. Heterogeneous panel causality analysis results support growth hypothesis in Bulgaria, Greece, Macedonia, Russia and Ukraine; feedback hypothesis in Albania, Georgia and Romania; neutrality hypothesis in Turkey and according to the panel data set including all nine countries the results support feedback hypothesis. With the findings, it was concluded that there is a significant impact of renewable energy consumption on economic growth in Balkan and Black Sea Countries.

1. Introduction

Energy is a vital production factor for all countries. Traditional energy sources like oil, natural gas and coal are considered to be the most effective drivers of economic growth (Ellabban et al., 2014). Social and economic developments in the last fifty years have rapidly increased the demand for traditional energy sources (Aslan et al., 2014). For example, while world energy demand is 4667 MTOE in 1973, this demand has risen to 9301 MTOE in 2013 by increasing two-fold. The share of oil, natural gas and coal are respectively 39.9%, 15.1% and 11.5% in meeting this demand in 2013. In other words, 65.5% of world energy need in 2013 was met with traditional energy sources (IEA, 2015). However, the world's dependence on traditional energy sources have brought many global problems. Today, energy independence and security of supply, energy price shocks, non-renewable features of oil, natural gas and coal as energy sources and global warming are considered the most fundamental global issues (Sadorsky, 2009).

On the other hand, these issues forced societies to find alternative energy sources to conventional energy sources (Bilgili and Ozturk, 2015; Ozturk and Bilgili, 2015). At this point attention to renewable energy as a significant alternative source has increased (Apergis and Payne, 2010). The substitution of traditional energy sources with renewable energy sources has emerged as a major solution tool (Yildirim, 2014). In this context, according to the optimistic scenario developed by the IEA, a 39% rise in electricity production from renewable sources by 2050 (with production by 18% in 2002) is expected. Thus, it is emphasized that 50% of global CO^2 emissions can be reduced and the increase in global temperature can be limited to the range of 2.0–2.4 °C. Therefore, renewable energy production and technologies have become the central element of the position of the energy policy. In recent years, production of renewable energy sources has been encouraged by state-funded subsidies, tax reduction and other support. These incentives reduced the production costs of renewable energy and in many countries renewable energy has become competitive with conventional energy. These developments have revealed many new entrepreneurs in the field of renewable energy throughout the world (Bhattacharya et al., 2016). The emerging trend in the global energy sector has led to a new debate about the role of the sustainable development of renewable energy sources (Lund, 2007; Sadorsky, 2009; Inglesi-Lotz, 2016). In terms of the outcomes of this discussion, it's important to understand the dynamics between renewable energy consumption and economic growth (Apergis and Payne, 2012). To date, a wide range of research area on the relationship between energy consumption and economic growth has occurred in the related literature (Ozturk, 2010; Sebri, 2015). However, studies based

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on renewable energy in this area are limited. Therefore, renewable energy has created a large interest among both academics and policy analysts (Bhattacharya et al., 2016). This interest has been the motivation of our work. The aim of this study is to explore the relationship between renewable energy consumption and economic growth for Albania, Bulgaria, Georgia, Greece, Macedonia, Romania, Russia F., Turkey and Ukraine that compose nine Black Sea and Balkan countries in the period of 1990–2012. The literature contribution and importance of this work comes from three points:

First, countries and regions involved in the research are chosen purposely, not randomly. Yet, why have these nine countries been selected? Because, these nine countries in the Black Sea and the Balkan region have a population of 317.2 million and constitute production volume of 2129 billion dollars. Moreover, these countries produced a 1004,67 MTOE energy in 2013 and caused 2287,63 mt CO_2 emission. According to these data, these nine countries alone constitute 4.5% of world population, 3.8% of production (GDP), 7.7% of energy demands and 7.1% of CO_2 emission (IEA, 2015). For this reason, the outcomes of this study will provide valuable deductions for economic growth, energy security and global warming in both domestic and global level.

Second, in the literature, the dynamic relationship between economic growth and renewable energy is explained through a panel composed by choosing certain countries. However, this approach is criticized as the countries that compose the panel are largely heterogeneous (Bhattacharya et al., 2016). Taking this criticism into consideration, in this study causality relation between renewable energy consumption and economic growth will be explored using heterogeneous panel causality estimation techniques developed by Dumitrescu and Hurlin (2012). Thus, empirical evidence will be presented for both panel and individual countries.

Third, in the last few years, renewable energy-economic growth research field has been quite attractive especially by the availability of the renewable energy data (Sebri, 2015). The relationship between renewable energy and economic growth has been examined in a number of studies (Aslan and Ocal, 2016). However, as far as we know, it seems there is a research gap in the literature in terms of renewable energy and economic growth relationship in the Black Sea and Balkan countries (see Table 1). This study aims to fill in this gap in the literature.

In this frame, the rest of the paper is arranged as follows: Section 2 introduces literature on the renewable energy and economic growth relationship. Section 3 presents model and data. Section 4 describes econometric methodology. Section 5 yields estimation results, and Section 6 evaluates main findings and provides some policy suggestions.

2. Literature review

In the last years, the increasing energy security, the extinction risk of traditional energy sources, greenhouse gas emission and other environmental problems made it obligatory to replace the traditional energy sources with renewable energy sources. Therefore, it is significant to understand the relationship between renewable energy consumption and economic growth in terms of revealing the dependence of the economy on energy and designing the energy policies (Yildirim and Aslan, 2012). In this frame, the literature is explored through four testable hypotheses in order to explain the direction of the relationship between energy consumption and economic growth. (Ozturk, 2010; Wesseh Jr. and Zoumara, 2012; Shahbaz et al., 2015):

i. Growth Hypothesis is valid when there is a one-way causality relationship from energy consumption to economic growth. According to this hypothesis, energy consumption as a complement of labor and capital has a significant impact on economic growth. In this case, policies that provide energy saving or energy supply shocks affect economic growth in a negative way.
ii. The conservation Hypothesis is valid when there is one-way causality relationship from economic growth to energy consumption. According to this hypothesis, economic growth is a factor that supports energy consumption and in this case energy saving and energy supply shocks don't affect economic growth in a negative way.
iii. Feedback Hypothesis is valid when there is a two-way/mutual causality relationship between energy consumption and economic growth. According to this hypothesis, energy saving policies and energy supply shocks affect economic growth is a negative way and accordingly this negativity is reflected in energy consumption.
iv. Neutrality Hypothesis is valid when there is no causality relationship between energy consumption and economic growth. In this case, decrease in energy consumption doesn't have any effect on economic growth.

Considering these hypotheses, results regarding energy-economic growth have differed for countries and no consensus has been achieved in the literature (Bhattacharya et al., 2016). The studies were seen to differ in terms of countries examined, time period, energy types, econometric methods and results (Ozturk, 2010). Bhattacharya et al. (2016) emphasized that a literature in energy consumption and economic growth developed largely in the last ten years, yet studies in the aforementioned literature that explain the impact of renewable energy on sustainable economic growth is not enough. Taking this emphasis into account, this study will evaluate the literature that examines the relationship between renewable energy and economic growth. In this context, Apergis and Payne (2010, 2011, 2012) reached some results that support the feedback analysis between renewable energy and economic growth using panel co-integration, panel dynamic least squares (DOLS), fully modified least squares (FMOLS) and panel vector error correction (VEC) methods for, in this order, 20 OECD, 6 Central America and 80 randomly chosen countries. Similarly, using panel data analysis, Salim and Rafiq (2012) in 1980–2006 period 6 major emerging economies; Al-mulali et al. (2014), in 1980–2010 period 18 Latin American countries and Shahbaz et al. (2016) in 1991Q1–2015Q4 period BRICS countries have found a two-way relationship between renewable energy consumption and economic growth. Pao and Fu (2013) examined the relationship between renewable energy consumption and economic growth in 1980–2010 period in Brazil using time series analysis method. The study gained data that supports feedback hypothesis. There were similar results in Lin and Moubarak's (2014) study for China and Shahbaz et al.'s (2015) study for Pakistan.

Payne (2009), gained results that support neutrality hypothesis in 1946–2006 period for USA using Toda-Yamamoto causality method. Ocal and Aslan (2013) and Dogan (2015) gained similar data for Turkey. Menegaki (2011) in his panel data study consisting of 27 European countries couldn't find a significant relationship between renewable energy and economic growth.

Bilgili (2015) examined the relationship between renewable energy and industrial production in 1981–2013 period in the USA with monthly data using wavelet coherence method and gained results that support the growth hypothesis. Bilgili and Ozturk (2015) and Ozturk and Bilgili (2015) found that renewable energy had a positive impact on economic growth in 1980–2009 period in G7 and 51 sub-Saharan African countries using panel co-integration, panel OLS and panel DOLS. Similarly, Inglesi-Lotz (2016) for 34 OECD countries and Hamit-Haggar (2016) for 11 sub-Saharan African countries gained data that support growth hypothesis. Bhattacharya et al. (2016) in this study for 1991–2012 period 38 top renewable energy consuming countries that takes into consideration the linear cross-section dependence and heterogeneity found that renewable energy consumption has a positive impact on economic growth in the 57% of the countries at hand.

Sadorsky (2009) found a one-way causality relationship from

Table 1
Literature on the relationship between renewable energy consumption and economic growth.

Author (s)	Country/Region	Period	Methodology	Conclusion
Payne (2009)	USA	1949–2006	Toda-Yamamoto	neutrality
Sadorsky (2009)	18 emerging countries	1994–2003	Panel cointegration, panel DOLS, panel FMOLS, panel VEC	conservation
Apergis and Payne (2010)	20 OECD countries	1985–2005	Panel cointegration, panel FMOLS, panel VEC	feedback
Menegaki (2011)	27 European countries	1997–2007	random effect	neutrality
Apergis and Payne (2011)	6 Central American countries	1980–2006	Panel cointegration, panel FMOLS, panel VEC	feedback
Tiwari (2011)	India	1960–2009	Structural VAR	conservation
Tugcu et al. (2012)	G7 countries	1980–2009	Cointegration and Hatemi-J causality	Mix results
Salim and Rafiq (2012)	6 major emerging economies	1980–2006	Panel cointegration, panel DOLS, panel FMOLS, Granger causality	feedback (short-run)
Apergis and Payne (2012)	80 countries	1990–2007	Panel cointegration, panel FMOLS, panel VEC	feedback
Pao and Fu (2013)	Brazil	1980–2010	cointegration and VEC	feedback
Ocal and Aslan (2013)	Turkey	1990–2010	Cointegration and Toda-Yamamoto	neutrality
Al-mulali et al. (2013)	High, upper-middle, lower middle and low income countries	Different periods	FMOLS	Feedback (79% of the countries) Neutrality (19% of the countries) Conservation (2% of the countries)
Lin and Moubarak (2014)	China	1977–2011	Cointegration and VEC	feedback
Al-mulali et al. (2014)	18 Latin American countries	1980–2010	Panel cointegration, panel DOLS, panel VEC	feedback
Bilgili (2015)	USA	1981–2013	wavelet coherence	growth
Shahbaz et al. (2015)	Pakistan	1972Q1–2011Q4	Cointegration and VEC	feedback
Dogan (2015)	Turkey	1990–2012	Cointegration and VEC	neutrality
Bilgili and Ozturk (2015)	G7 countries	1980–2009	Panel cointegration, panel OLS and panel DOLS	growth
Ozturk and Bilgili (2015)	51 Sub-Sahara African countries	1980–2009	Panel cointegration, panel OLS and panel DOLS	growth
Aslan and Ocal (2016)	New EU member 7 countries	1990–2009	Cointegration and Hatemi-J causality	Mix results
Shahbaz et al. (2016)	BRICS countries	1991Q1–2015Q4.	Panel cointegration, fixed effect and panel VEC	feedback
Inglesi-Lotz (2016)	34 OECD countries	1990–2010	Panel cointegration, fixed effect and pooled estimation	growth
Hamit-Haggar (2016)	11 Sub-Saharan African countries	1971–2007	Panel cointegration, OLS, DOLS, FMOLS, DSUR and bootstrap-corrected Granger	growth
Bhattacharya et al. (2016)	38 top renewable energy consuming countries	1991–2012	Panel cointegration, panel FMOLS, DOLS and Dumitrescu-Hurlin causality	renewable energy has a significant positive impact on the economic output (57% of the countries) neutrality (short-run)

economic growth to renewable energy consumption in 1994–2003 period 18 emerging countries. Similarly, Tiwari (2011) gained data that supports conservation hypothesis in 1960–2009 period India using Structural vector autoregressive model (VAR) method. Al-mulali et al. (2013) examined the renewable energy consumption and economic growth in various periods in High, upper-middle, lower middle and low income countries that he divided into 4 groups using FMOLS method. He gained results that support the conservation hypothesis in 2% of the countries, neutrality hypothesis in 19% of the countries and feedback hypothesis in the remaining 79%. Tugcu et al. (2012) examined the relationship renewable energy consumption and economic growth in 1980–2009 period G7 countries in the case of classical production function and augmented production function using co-integration and Hatemi-J causality method. For all countries in the case of classical production function he gained results that support feedback hypothesis. In the case of Augmented production function, he gained results that support neutrality hypothesis for France, Italy, Canada and the USA; feedback hypothesis for Great Britain and growth hypothesis for Germany. Similarly, Aslan and Ocal (2016) gained mix results for 1990–2009 period and new EU member 7 countries using Hatemi-J causality method. Neutrality hypothesis for Southern Cyprus, Estonia, Hungary, Poland and Slovenia; growth hypothesis for Czech Rep.; and conservation hypothesis for Bulgaria were supported.

Table 1 shows the summary of the Literature on the relationship between renewable energy consumption and economic growth.

One may notice that the literature of energy summarized in Table 1 does not reveal any evidence on the renewable energy and economic growth in Black sea and Balkan Countries. This revealed gap is the source of motivation for the writers, and thus the study aims to contribute to the literature in this way.

3. Model and data

In this study, the relationship between renewable energy and economic growth will be examined using neo-classic production function. In this context, the production function that labor, capital, and renewable energy is considered individual input is defined as follows.

$$Y = f\,(K_{it},\, L_{it},\, RE_{it}) \tag{1}$$

In the Eq. (1), Y stands for economic growth or GDP per capita, K stands for capital stock, L stands for labor and RE stands for renewable energy. Equation number (1) was transformed in to a log-linear specification by taking all the variable's logarithms. This transformation has provided us with the following benefits, (i) problems related to dynamic qualifications of the data set are avoided (Bhattacharya et al., 2016), (ii) log-linear specification gives more consistent and efficient empirical results (Shahbaz et al., 2012). For these reasons equation number (1) is modeled as log-linear function as follows:

Table 2
Descriptive statistics and correlation matrix for variables.

Descriptive statistics	lnY	lnK	lnL	lnRE
Mean	3.558	3.074	15.671	1.018
Median	3.525	3.136	15.397	1.122
Maximum	4.385	3.624	18.163	1.759
Minimum	2.833	−1.203	13.601	−0.221
Std. Dev.	0.347	0.458	1.395	0.479
Observations	207	207	207	207
Correlation matrix				
lnY	1			
lnK	0.190	1		
lnL	0.224	0.097	1	
lnRE	−0.078	−0.021	−0.596	1

$$lnY_{it} = \beta_{1i} lnK_{it} + \beta_{2i} lnL_{it} + \beta_{3i} lnRE_{it} + \varepsilon_{it} \tag{2}$$

In the equation number (2) i and t indexes show the number of the countries and the time period. β_1, β_2 and β_3 are, in this turn, revenue resilience of capital, labor and renewable energy consumption and ε is the error term.

This paper employs data for 9 countries (Albania, Bulgaria, Georgia, Greece, Macedonia, Romania, Russian F., Turkey and Ukraine) for the period 1990–2012. We used; per capita GDP growth (constant 2005 US Dollars) for economic growth, gross fixed capital formation (% of GDP) for capitalization (K), labor force participation rate (% of total population ages 15–64) for labor (L) and the share of renewable energy in total energy consumption (%) for renewable energy consumption (RE). All data in the study is taken from the World Bank database.

Table 2 shows the descriptive statistics and correlation matrix. One notes that all descriptive statistics of lnL are greater than those of lnY, lnK and lnRE. One may notice, as well, that lnY is positively correlated with lnK and lnL while the lnY is negatively correlated with lnRE.

It is aimed to show some of the beginning or preliminary information with the descriptive statistics and correlation matrix. However, beyond the observations in Table 2, more reliable statistical methods, such as root, co-integration and causality analysis, is required for attaining more unbiased and efficient data to researching the relationship between the variables.

4. Econometric methodology

In this study, we will use the panel date analysis method to research the long-term relationship between renewable energy consumption and economic growth in the Black Sea and Balkan countries. In this analysis, (i) stability of the series will be tested with the panel unit root tests, (ii) examined with long-term relationship panel co-integration method, (iii) long term parameters will be estimated with panel FMOLS and DOLS, (iv) causality relationship will be researched by the Dumitrescu and Hurlin (2012) method.

4.1. Panel unit root test

The first step of econometric analysis is to explore the stability of series used in the analysis. In this context, we employ panel unit root tests developed by Levin et al. (2002, LLC) and Im et al. (2003, IPS).

For the LLC (2002) panel unit root test, a panel model like below is estimated:

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{pi} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it}, \quad m = 1, \ 2, 3. \tag{3}$$

In the equation number (3) ε_{it} is uncorrelated throughout the units and follows an ARMA process. Δ shows the first-differences, d_{mt} shows dummy variables for each unit, α_{mi} shows their parameters. Δy_{it} and Δy_{it-1} have individual regressions with Δy_{it-L} and residuals are attained. Here L ($L=1,2,..,P_i$) stands for the optimal lag length defined by information criteria. Zero hypothesis and alternative hypothesis for this test is as follows:

H_o: ρ=0 for all i (includes series unit root).
H_1: $\rho < 0$ for all i (doesn't include series unit root).

When the zero hypothesis is rejected, it is determined that series doesn't have unit root, in other words that it is stable. These hypotheses are tested with t statistics. Lastly the t statistics that were calculated are compared with Levin et al. (2002) critical values.

IPS (2003) performs unit root test on time series individually for all units and tests statistics are obtained from average of all statistics of all individual ADF tests.

IPS (2003) test is obtained from the model below:

$$\Delta y_{it} = \delta_i y_{it-1} + \sum_{L=1}^{pi} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it}, \quad m = 1, \ 2, \ 3. \tag{4}$$

Ho: ρ=0 for all i (includes series unit root).
H_1: $\rho < 0$ at least one or some of the i (doesn't include series unit root).

In order to test the zero hypothesis in IPS (2003) test, first of all the t-statistic of ρi coefficient for each cross-section is calculated. Secondly, average of the ADF test statistics is taken and lastly normalization is performed in order for test statistics to have a standard normal distribution. A decision as to the zero hypothesis is made according to the test statistic results.

4.2. Panel cointegration test

As a result of the unit root analysis series can either be stable at the level value [I(0)] or at the first-differences [I(1)]. If they are stable at the level value, the relationship between the variables is estimated by the traditional OLS method. If the series are stable at the first-differences, the co-integration relationship between the variables should be explored.

Panel co-integration test suggested by Pedroni (1999, 2004) is a method that is often used to analyze the long-term co-integration relationship between the dependent and independent variables in the panel data set. In the Pedroni (1999, 2004) panel co-integration tests zero hypothesis and alternative hypothesis is defined as follows:

Ho: there is no co-integration relationship for all i.
H_1: there is a co-integration relationship for all i.

In order to test the Pedroni (1999, 2004) zero hypothesis 7 different test statistics are developed using the residuals obtained from the panel co-integration regression. Four of these tests consist of in-group (panel-v, panel-ρ, non-parametrical panel-t and parametrical panel-t) statistics; other there of them consist of intergroup (group- ρ statistics, non-parametrical group-t statistics and parametrical group-t) statistics. In case the panel-v statistics has a high positive value and the other statistics have a higher and negative value, zero hypothesis that is defined as no co-integration relationship is rejected and it is determined that there is a long-term relationship between the variables .

4.3. Estimation of long-run parameters

After determining the co-integration relationship, it is necessary to estimate the lon-term parameters for the relationship between the variables. In the literature panel FMOLS and panel DOLS methods developed by Pedroni (2000, 2001) are used very often.

The group average panel FMOLS method developed by Pedroni (2000) is based on the panel regression model below:

$$y_{it} = \alpha_{it} + \delta_{it} t + \beta x_{it} + \mu_{it} \quad (5)$$

$$x_{it} = x_{it-1} + e_{it} \quad (6)$$

The equations number (5) and (6) shows; y_{it} dependent variable, x_{it} independent variable, α_i constant effects and β long-term co-integration vector/coefficient that should be estimated under the assumption that there is no dependence between sections that consists the panel. In this context panel FMOLS estimator is formed as below:

$$\hat{\beta}^*_{GFM} = N^{-1} \sum_{i=1}^{N} \hat{\beta}^*_{FM,i} \quad (7)$$

In the equation number (7) $\hat{\beta}^*_{FM,i}$ stands for the FMOLS estimation result obtained for cross section that forms the each i'th panel. Then, co-integration coefficient for the overall panel is estimated by taking the average of the FMOLS coefficients obtained for the cross section. T statistic for the panel co-integration coefficient is calculated as follows.

$$t_{\hat{\beta}^*_{GFM}} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}^*_{FM,i}} \quad (8)$$

In the equation number (8) $t_{\hat{\beta}^*_{GFM}}$ stands for the t statistic for co-integration coefficient obtained for the overall panel.

DOLS estimator developed by Pedroni (2001) is based on the panel regression model below:

$$y_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-K_i}^{K_i} \gamma_{ik} \Delta x_{it-k} + \varepsilon_{it} \quad (9)$$

When estimating the panel co-integration coefficient, first of all Eq. (9) is estimated for each cross section. Secondly, co-integration coefficient for the overall panel is obtained by taking the average of the DOLS coefficients obtained for each coefficient. In this context, panel DOLS estimator is formed as follows:

$$\hat{\beta}^*_{GD} = N^{-1} \sum_{i=1}^{N} \hat{\beta}^*_{D,i} \quad (10)$$

In the equation number (10) $\hat{\beta}^*_{D,i}$ stands for the DOLS estimate result obtained for the cross section that forms each i'th panel. t statistic for the significance of the long term parameter is calculated as below:

$$t_{\hat{\beta}^*_{GD}} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}^*_{D,i}} \quad (11)$$

In the equation number (11) $t_{\hat{\beta}^*_{GD}}$ stands for t statistic for co-integration coefficient obtained for overall panel.

4.4. Heterogeneous panel causality test

Next step in determining the long-term relationship between variables is to define the direction of the relationship by causality analysis. For this, the causality test developed by Dumitrescu and Hurlin (2012) and based on Wald statistics will be used. The significant advantage of this test is that it takes into consideration the dependence among the countries and heterogeneity. Moreover it can be performed when the time dimension (T) is higher or lower than the cross section dimension (N) as well. In this method analysis is performed with two stable series, and if the series used in the analysis are not stable, they should be stabilized by taking their discrepancy.

In the Dumitrescu and Hurlin (2012) panel causality analysis, zero hypothesis and alternative hypothesis are defined as follows:

$H_0 = \beta_i = 0 \ \Lambda_i = 1, \ldots, N$ there is no causality relationship form x to y
$H_1: \beta_i = 0 \ \Lambda_i = 1, \ldots, N_1$
$\beta_i \neq 0 \ \Lambda_i = N_1 + 1, N_1 + 2, \ldots, N$ there is a causality relationship form x to y for some cross sections.

In order to test the Dumitrescu and Hurlin (2012) zero hypothesis, firstly, individual Wald statistics for each cross-section is calculated. These statistics give the causality relationship for each cross-section. Then, the Wald statistic ($W^{Hnc}_{N,T}$) that is valid for the panel is obtained by taking the average of the individual Wald statistics. (see Eq. (12))

$$W^{Hnc}_{N,T} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \quad (12)$$

Dumitrescu and Hurlin (2012) suggests using the (T>N) test statistic when the time dimension is higher than the cross section dimension and the (T<N) test statistic when the time dimension is lower than the cross section dimension. As T > N in this study, the test statistic that is standardized under this condition is shown below (see Eq. (13)):

If T > N,

$$Z^{Hnc}_{N,T} = \sqrt{\frac{N}{2K}} (W^{Hnc}_{N,T} - K) \rightarrow N(0,1) \quad (13)$$

Dumitrescu and Hurlin (2012) calculates the test statistics and the probability values for these statistics using Monte-Carlo simulation.

5. Estimation results

Table 3 shows the results for panel unit root test. Unit tests give different results in terms of the stability of level values of the series. However, all statistics show that the series are stable at the first difference. In other words, the series are integrated of first order ([I(1)]. In this case, a long term balance relationship between the variables is possible. That's why; in the next level the co-integration relation between the variables is examined.

Table 4 shows the panel co-integration test results. According to the test results 4 of the 7 test statistics support the co-integration relationship between lnY, lnK, lnL and lnRE. ın other words, despite the shocks that affect the system in the short term, a balance relation in the long term between the variables seems possible. In this case, the next level is to estimate the long term parameters.

Table 5 shows the estimate results for panel DOLS and panel FMOLS. Both estimation methods give similar results. According to the panel FMOLS results, coefficient for lnK, lnL and lnRE are positive and significant statistically at the 1%level of significance. These findings show that capital, labor and renewable energy has a positive and significant impact on economic growth in 9 Black Sea and Balkan countries in 1990–2012 period.

Panel co-integration test and coefficient estimate show information regarding the direction of the relationship between lnY and lnK, lnL and lnRE. In this context, the results of the heterogeneous panel causality test that is developed by Dumitrescu and Hurlin (2012) for defining the direction of the relationship is presented in Table 6.

Table 3
Panel unit root test results for 9 Black sea and Balkan Countries (1990–2012).

Variable	LLC[a]		IPS	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
lnY	0.605	−10.379[b]	1.723	−7.006[b]
lnK	0.387	−1.971[c]	−0.582	−1.777[c]
lnL	−2.083[c]	0.984	0.933	2.261
lnRE	−3.537[b]	2.232	−2.534[b]	0.209
ΔlnY	−9.075[b]	−6.055[b]	−6.542[b]	−3.301[b]
ΔlnK	−11.051[b]	−7.535[b]	−12.039[b]	−7.457[b]
ΔlnL	−6.044[b]	−7.131[b]	−6.285[b]	−6.936[b]
ΔlnRE	−10.845[b]	−11.421[b]	−10.002[b]	−9.214[b]

Notes:
[a] Newey-West Bandwidth selection with Bartlett Kernel is used for LLC test.
[b] Illustrates 1% statistical significance.
[c] Illustrates 5% statistical significance.

Table 4
Panel co-integration test results for 9 Black sea and Balkan Countries (1990–2012).

Test[a]	statistic	Probability
Panel v-Statistic	−0.016	0.506
Panel rho-Statistic	1.070	0.857
Panel PP-Statistic	−3.004[b]	0.001
Panel ADF-Statistic	−4.602[b]	0.000
Panel rho-Statistic	1.655	0.951
Group PP-Statistic	−2.871[b]	0.002
Group ADF-Statistic	−3.835[b]	0.000

Notes:
[a] Newey-West Bandwidth selection with Bartlett Kernel is used.
[b] Illustrates 1% statistical significance.

Table 5
Panel long-run parameters for 9 Black sea and Balkan Countries (1990–2012).

Variable	Panel DOLS		Panel FMOLS	
	Coefficient	t-statistic	Coefficient	t-statistic
lnK	0.220[b]	2.488	0.281[a]	3.211
lnL	0.165[a]	10.112	0.154[a]	9.561
lnRE	0.269[a]	3.238	0.251[a]	2.988

Notes:
[a] Illustrates 1% statistical significance.
[b] Illustrates 5% statistical significance.

According to the test results for the panel, there is a one-way causality relationship from lnK to lnY, a two-way (feedback) causality relationship between lnL and lnY and between lnRE and lnY. These results support the feedback hypothesis between renewable energy consumption and economic growth in 9 Black Sea and Balkan countries in 1990–2012 period.

Evaluating the results particular to countries:

(i) Between lnK and lnY, is seen in Greece, Macedonia, Russian F., Turkey and Ukraine, and a one-way relationship from lnY to lnK in Albania. There was no causality relationship for Bulgaria, Georgia and Romania. According to this, increase in capital stock encourages economic growth in Greece, Macedonia, Russian F., Turkey and Ukraine, and economic growth supports capital accumulation in Albania.

(ii) Between lnL and lnY, a one-way causality relationship from lnL to lnY is obtained for Albania, Bulgaria, Macedonia and Ukraine, and a one-way causality relationship from lnY to lnL is obtained for Georgia, Russian F. and Turkey. No findings were attained to support the causality relationship for Greece and Romania. According to these results, prompts economic growth in Albania, Bulgaria, Macedonia and Ukraine; economic growth prompts rate of participation to labor in Georgia, Russian F. and Turkey.

(iii) Between lnRE and lnY, there is a one-way causality relationship from lnRE to lnY for Bulgaria, Greece, Macedonia, Russia and Ukraine, and a two-way relationship for Albania, Georgia and Romania. There is no causality relationship for Turkey. When this findings are evaluated in the context of renewable energy-economic growth relationship, it is seen that growth hypotheses is supported in Bulgaria, Greece, Macedonia, Russia and Ukraine; feedback hypothesis is supported in Albania, Georgia and Romania and neutrality hypothesis is supported in Turkey. According to this, renewable energy consumption supports economic growth in Bulgaria, Greece, Macedonia, Russia and Ukraine. Renewable energy consumption encourages economic growth and economic growth encourages renewable energy consumption in Albania, Georgia and Romania.

6. Conclusion and policy implications

Recently, global warming and climate change, energy supply security and limited reserves of petrol, coal and natural gas sources make it obligatory to replace traditional energy sources with alternative energy sources. Renewable energy source as an alternative source presents itself as an important potential. In this context the impact of renewable energy sources on economic growth in 1990–2012 period 9 Black Sea and Balkan countries is explored in the frame of traditional production function. Within the context of the research, first of all it is seen that the series are stable at the first discrepancy by the panel unit root test. Pedroni (1999, 2004) concluded that a long-term balance relationship between the variables is possible via panel cointegration test. The parameters for this relationship are estimated by the panel FMOLS method developed by Pedroni (2000, 2001) and panel DOLS method. According to the estimation results we reach the conclusion that renewable energy consumption has a positive impact on economic growth.

At the last stage of the empirical research the direction of the relationship between renewable energy consumption and economic growth is estimated by the panel causality analysis developed by Dumitrescu and Hurlin (2012) for both the heterogeneous panel and each country that constructs the panel. According to the results of the estimation it is seen that growth hypothesis is supported in Bulgaria, Greece, Macedonia, Russia and Ukraine; feedback hypothesis is

Table 6
Heterogeneous panel causality test results for Black sea and Balkan Countries (1990–2012).

Countries	lnK→lnY	lnY→lnK	lnL→lnY	lnY→lnL	lnRE→lnY	lnY→lnRE
	Wald stat.	Wald stat.	Wald stat.	Wald stat.	Wald stat.	Wald stat.
Albania	1.440	6.006[b]	6.348[a]	0.347	16.803[a]	13.484[a]
Bulgaria	0.021	2.851	20.797[a]	0.012	12.907[a]	0.227
Georgia	0.018	0.103	5.656b	8.712[a]	33.213[a]	6.894[a]
Greece	9.264[a]	1.395	0.107	0.008	35.837[a]	2.438
Macedonia	4.555[b]	1.485	25.315[a]	0.001	9.386[a]	0.011
Romania	1.899	1.065	0.081	2.593	5.806[b]	2.724[c]
Russian F.	50.031[a]	2.461	0.041	5.014[b]	10.112[a]	0.417
Turkey	4.728[b]	1.754	5.087b	5.642[b]	0.452	1.804
Ukraine	34.214[a]	2.828	30.777[a]	30.562[a]	3.094c	1.017
Panel	22.942[a]	1.58	20.084[a]	10.345[a]	27.957[a]	4.718[a]

Notes:
"→" means the direction of the causality relationship.
[a] Illustrates 1% statistical significance.
[b] Illustrates 5% statistical significance.
[c] Illustrates 10% statistical significance.

supported in Albania, Georgia and Romania, and neutrality hypothesis is supported in Turkey. We also concluded that the feedback hypothesis is valid for the panel consisting of 9 Black Sea and Balkan countries. According to this hypothesis, in the Black Seal and Balkan countries, renewable energy consumption encourages economic growth and economic growth encourages renewable energy consumption. These results suggest that renewable energy sources are an important potential in terms of sustainable development in Black Sea and Balkan countries.

Within the frame of the findings, the main recommendation of this study is that policies as to replace traditional energy sources with renewable energy sources should be supported in the Black Sea and Balkan countries. For example, the share of renewable energy sources among the total energy sources in Russia, which is an important global CO2 emitter country, was 3% by 2012 (IEA, 2015). On the other hand Albania, Bulgaria, Georgia, Greece, Macedonia, Romania, Turkey and Ukraine redress energy balance by import (IEA, 2012). For this reason, supports will provide in terms of not only economic growth, but also energy supply security and providing of energy independence and improving environmental quality. In this context, authorities may adopt these policies (Bilgili, 2012; Bilgili etal. 2016): (i) Practices like the tax incentives under the energy policies in the USA can be followed. (ii) Enhanced subventions can be adopted for renewable energy sources. (iii) Sectoral incentives that will increase especially biomass production in the agriculture sector can be provided. (iv) Systems that will provide an easier and fairer access to the electricity that is produced from renewable energy sources can be supported. (v) Various tariff support can be provided for renewable energy use and green certificate trading can be supported. In the long-run Remittance policies as to improving renewable energy technologies and investments and other financial aids can be performed.

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