The relationship between renewable energy consumption and economic growth

The case of Bulgaria

Hamit Can
Technical University of Sofia, Sofia, Bulgaria, and

Özge Korkmaz
Bayburt Universitesi, Bayburt, Turkey

Abstract

Purpose – The purpose of this study is to investigate the relationship between renewable energy and economic growth of Bulgaria.

Design/methodology/approach – This study analyzes the relationship between renewable energy and economic growth of Bulgaria for the period 1990-2016, based on annual data, by using the Toda–Yamamoto analysis and Autogressive Distributed Lag (ARDL) bound test. This period is characterized by the democratization of the Balkans and several crisis cycles in Bulgaria. Renewable energy consumption (REC, percentage of total final energy consumption), renewable electricity output (REO, percentage of total electricity output) and economic growth (GDP constant 2010 US$) were used. The levels or differences of the variables that are stationary were investigated using the augmented Dickey–Fuller (ADF), Philips–Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests.

Findings – Three different results were obtained from this study. One showed that renewable energy consumption and renewable electricity output are the causes of economic growth. Another result of this study is that economic growth and renewable electricity output are the causes of renewable energy consumption. The last result is that economic growth and renewable energy consumption are not causes of renewable electricity output. There was no long-term relationship between variables.

Research limitations/implications – The ARDL and Toda–Yamamoto tests were used because of lack of data sets. Thus, it is estimated that there is no long-term relationship.

Originality/value – This study is an original work for Bulgaria, showing the results of the relationship between renewable energy and economic growth. In line with the results of this study, renewable energy projects related to Bulgaria can be predicted.

Keywords Economic growth, Renewable energy, ARDL bound test, Bound tests, Macroeconomic influence, Toda-Yamamoto causality analysis

Paper type Research paper

Variability in energy economies leads to more frequent use of renewable energy technologies in the context of sustainable energy. Renewable energy production and consumption enable the development of new technologies. Therefore, there are many new opportunities for investors and the economy in general. Renewable energy production and consumption have a multiplier effect not only on the energy sector but also on all supporting activities related to this sector. The aim of this study is to analyze the effects of renewable energy production and consumption on economic growth. Besides, the positive effects of these technologies in the economy are investigated. Unlike previous renewable energy-
growth studies, this is the first study that examines the relationship between renewable energy and economic growth of Bulgaria by using the Toda–Yamamoto analysis and ARDL bound test, which indicates that there is positive long-run causality running from renewable energy to real GDP. The used data set involves the Republic of Bulgaria’s national statistical data for the period from 1990 to 2016. In this period, Bulgaria experienced a collapse of the socialist system. Then, the use of modern energy has been taken into consideration. This process has been accelerated by the moments of specific crises that change and reduce the expectations of sustainable growth. This means that democratization of the Balkans and some crisis cycles in Bulgaria played important roles in the shift to renewable energy technologies. The data used in econometric analysis have been taken on the website of the World Bank. Only the natural logarithm of the GDP constant 2010 US$ variable has been taken from the variables used in the econometric analysis. Other variables are based on the ratio of renewable energy consumption (REC, percentage of total final energy consumption) and renewable electricity output (REO, percentage of total electricity output).

1. Introduction
Consumption continues to increase with the needs of countries with high levels of development. It is estimated that this increase will continue in line with predictions. Along with the necessity of meeting the consumption needs of countries and adapting to technological developments, energy consumption should increase. While energy consumption is met by a high proportion of fossil energy sources, meeting energy requirements at low rates from renewable energy sources has increased future concerns within the scope of sustainable energy. Moreover, the studies on energy economy and the country’s energy policies are progressing in this direction. Uncertainty of fossil resources, dependence on countries’ imports, political crises and the negative impact of fossil resources on the environment constitute the bases of concerns. According to scientific studies, the findings of positive effects of the use of renewable energy on the economy and the environment are increasing day by day. Besides, according to the policies after the oil crisis, distrust on access to fossil fuels has raised the issue of energy diversity, and the dependence on fossil resources has been sought to be avoided. A great part of the solution proposals has the tendency to shift to renewable and cheaper energy sources. In the context of sustainable energy, the use of renewable energy sources is essential for meeting the energy needs of Bulgaria and other countries.

According to the literature, the effects of renewable energy consumption and production on economic growth have been examined for Bulgaria. Through literature research, it was observed that there was no study examining the relationship between the variables used in the study in this period for Bulgaria. The hypothesis that “the increase in the production and consumption of renewable energy in Bulgaria can lead to a sustainable growth in the Bulgarian economy” was analyzed in this study.

The characteristics of the study that may be considered as different from those of the studies examining the same subject can be stated as follows:

- There is no such empirical work for the case of Bulgaria to study the relationship between renewable energy and economic growth. The study is aimed to eliminate the lack of literature in this direction.
- Along with reducing negative effects of fossil fuels and the dependence on them, we predicted how the influence on the economy of the country would be equal to the transition in renewable energy use.
To raise awareness about Bulgaria’s policies toward renewable energy, in line with our results for Bulgaria, we aimed to raise awareness about the energy strategies and investments for both Bulgaria and other countries. Determining the importance of mitigating fossil resource dependence practices and renewable energy strategies to minimize the adverse effects of possible crises is important for energy economies. Emphasizing the importance of renewable energies in energy resources for countries, we aimed to create a perception in terms of the extent of investments to be made.

2. Literature review
In recent years, there have been factors that need to be considered in the studies investigating the relationship between energy consumption and economic growth. As each country has different domestic energy sources, different political regulations, different institutional arrangements, different cultures and different energy policies, it may be inappropriate to make general judgments when it comes to analyzing this relationship. When these methodologies are applied to countries with different economic backgrounds, conflicting results may be obtained. Energy prices are predicted to have a direct impact on the economic growth in countries without sufficient energy resources. In this context, the relationship between renewable energy and economic growth constitutes the theme of many literature studies within the scope of sustainable energy supply. In this context, the relationship of energy and growth within the scope of sustainable energy supply has been the subject of many scientific studies. Some of the empirical studies examining the relationship between renewable energy consumption and economic growth (GDP) are as follows.

Some of the literature studies have found that there is a long-term relationship between economic growth and energy consumption. For example, Al-mulali et al. (2013) used the data from 1980 to 2009 for 108 countries, examining the relationship between renewable energy consumption and growth. According to the study results, there was a bi-directional relationship between renewable energy consumption and growth for 85 countries. For 21 countries, there was no relationship between renewable energy consumption and growth. For two countries, there was a one-way relationship from growth to renewable energy consumption. In total, 79 per cent of the countries had a positive, bi-directional long-run relationship between renewable energy consumption and GDP growth. Shafiei and Salim (2014), using the data from 1980 to 2011 for 29 OECD countries, investigated the impacts of renewable and non-renewable energy consumption on economic growth and CO₂ emissions. According to the results, there was two-way causality between economic growth and both renewable and non-renewable energy consumption. Hassine and Harrathi (2017), from 1980 to 2012 for the Gulf Cooperation Council (GCC) countries, reported a causal relationship between renewable energy consumption, real GDP, trade and financial development. It is estimated that renewable energy consumption, exports and private sector credit have significant impacts on output. Furthermore, it is foreseen that the renewable energy use and exports may increase the economic growth of GCC countries.

Fotourehchi (2017), using the data from 1990 to 2012 for 42 developing countries, analyzed the relationship between renewable energy consumption and economic growth. According to the results, there was one-way causality between renewable energy consumption and economic growth. Khobai and Le Roux (2018), using the data from 1990 to 2014 for South Africa, investigated the causal relationship between renewable energy consumption and economic growth. According to the results, there is a long-term...
relationship between the variables. The long-run results show that a one-way causality relationship from renewable energy consumption to economic growth has been identified, and the short-run results show that there was one-way causality from economic growth to renewable energy consumption.

*Kraft and Kraft (1978)* survey has guided many studies examining the relationship between growth and energy consumption (*Belloumi, 2009*). *Papiez and Smiech (2013)*, using the data from 1993 to 2011 for post-communist countries, investigated the relationship between energy consumption and economic growth. According to the results, there was a linkage between energy consumption and economic growth in four out of nine countries. The growth hypothesis was positive for three countries: Bulgaria, Poland and Romania. A special situation of Poland and Bulgaria – countries confirming the growth hypothesis – should be mentioned. They rely on coal as the most important source of energy. *Smiech S. and Papież M. (2014)* used the data from 1993 to 2011 for European Union (EU) member states for investigating the relationship between energy consumption and economic growth. The results indicate that the group of countries with the highest reduction of energy intensity and share of renewable energy in total energy consumption had causal relations. There was no causality relationship between variables in 17 countries. For Latvia and Bulgaria, it was stated that there was a bi-lateral causality relationship between the variables. *Sasana and Ghozali (2017)*, using the data from 1995 to 2014 for five BRICS countries, analyzed the effect of the consumption of fossil fuels and renewable energy on the economic growth. The results show that the consumption of fossil energy had a positive effect on economic growth, while renewable energy consumption had a negative effect.

Other studies examining the relationship between renewable energy and economic growth are given below.

*Benavides et al. (2017)* used data from 1970 to 2012 for Austria, investigating short- and long-term relationships between CH4 emissions, economic growth, electricity production from renewable sources and trade openness. According to the results of the long-term Granger causality, one-way causes were found between CH4 and related variables. *Ohler and Fetters (2014)* used the data from 1990 to 2008 for 20 OECD countries, investigating the relationship between economic growth and electricity generation from renewable sources. The findings indicate that energy conservation policies would have a positive effect on GDP in certain circumstances. *Aguirre and Ibikunle (2014)*, using the data from 1990 to 2010 for a broader sample size of countries, worked on renewable energy growth. According to the results of the study, it was suggested that weak voluntary approaches may have negative effects on the growth of renewables to meet public demand.

*Apergis and Payne (2014)*, using the data from 1980 to 2010 for seven Central American countries, investigated that renewable energy consumption and CO2 emissions are cointegrated. *Zeb et al. (2014)*, using the data from 1975 to 2010 for Bangladesh, India, Nepal, Pakistan and Sri Lanka, investigated the relationship among electricity production from renewable sources, GDP, CO2 emissions, natural resource depletion and poverty. Findings show that there is two-way Granger causality between CO2 emissions and natural resource depletion in Nepal and between energy production and poverty in Pakistan. Also, the results pointed at Granger causality from energy production to poverty in Bangladesh and India and from poverty to energy production in Sri Lanka. *Fuinhas and Marques (2012)*, using the data from 1990 to 2007 for 24 European countries, stated that the high costs of promoting renewables are probably being placed excessively upon the economy, namely, by increasing electricity tariffs, thus inducing deceleration in economic activity. *Menyah and Wolde-Rufael (2010a)*, using the data from 1960 to 2007 for the USA, investigated the relationship between renewable and nuclear energy consumption and between real GDP and CO2
emissions. According to the study, renewable energy consumption does not contribute significantly to emission reduction. Menyah and Wolde-Rufael (2010b), using data from 1960 to 2007, in the study of the relationship between CO$_2$ emissions, renewable and nuclear energy consumption and real GDP, found that renewable energy consumption has made a significant contribution to emission reduction. Chien and Hu (2008), using the data of 2003 for 116 economies, stated that there was a positive relationship between renewable energy and GDP. Chien and Hu (2007), using the data from 2001 to 2002 for 45 economies, suggested that increasing the use of renewable energy improves an economy’s technical efficiency.

The relationship between economic growth and renewable energy consumption is the focus of recent research in terms of the fight against sustainable energy and environmental pollution. Determining the causality relationship between two variables is of high importance for policymakers. It is estimated that renewable energy has a direct or indirect effect on sustainability (Inglesi-Lotz, 2016; Stiglitz, 2002). Moreover, renewable energy can be seen as the main factor in overcoming the obstacles to sustainable development (energy price shocks, fossil energy, energy supply security, environmental pollution issues and so on).

Recently, most of the scientific studies have been about renewable energy, such as Payne (2009), Menyah and Wolde-Rufael (2010a, 2010b), Shahbaz et al. (2012) and Pao and Fu (2013). Most of the previous empirical studies investigating the effectiveness of renewable energy policies have focused on policies to promote renewable energy production and energy investments.


The studies that determine the causality relationship from renewable energy to economic growth are given below.

Tiwari (2011), using the data from 1960 to 2009 for India, investigated the relationship between renewable energy and GDP. The findings suggest that a positive shock in renewable energy source increases GDP. Bobinaite et al. (2011), using the data from 1990 to 2009 for Lithuania, investigated that in the short run, there was one-way causality running from renewable energy sources gross inland consumption to real GDP. According to the results, increased consumption of RES will have a positive effect on Lithuania’s real GDP. Ibrahiem (2015), using the data from 1980 to 2011 for Egypt, investigated the relationship between renewable electricity consumption, foreign direct investment and economic growth. According to the results, renewable electricity consumption had a positive effect on economic growth in the long run and there was two-way causality relationship between economic growth and renewable electricity consumption. Hamit-Haggar (2016), using the data from 1971 to 2007 for 11 sub-Saharan African countries, examined the relationship between clean energy consumption and economic growth. According to the results, it was stated that there is one-way Granger causality relationship from clean energy consumption to economic growth. Bhattacharya et al. (2016) investigated the relationship between renewable energy consumption and economic growth by using data from 1991 to 2012 for 38 countries with high renewable energy consumption. They stated that renewable energy had a significant impact on economic growth, and that governments and other related installations and organizations should act together in determining renewable energy
policies. According to the research results, there is a one-way relationship from renewable energy consumption to economic growth for some countries and the long-term increase in renewable energy consumption has a significant impact on economic output. Naseri et al. (2016), using the data from 1990 to 2012 for OECD countries, investigated the impact of renewable energy intermediate consumption on economic growth. Findings show that an increase in renewable energy consumption leads to increase in economic growth. Brozyna et al. (2017), using the data from 2004 to 2014 for 28 EU countries, investigated whether and to what extent economic development stimulates the production of energy from renewable sources. Findings showed that in each group, the production of energy from renewable sources rose and the production of greenhouse gases fell over the 10-year period. This was achievable despite the economic crisis. The EU directive from 2009 did not clearly impact investment in renewable energy in comparison with the five years preceding it. This should be interpreted positively as it shows investor awareness in this area in different countries, regardless of top-down regulation. Kahia et al. (2017), using the data from 1980 to 2012 for 24 economies, investigated the effects of renewable energy policies on economic growth in MENA countries. According to the study, the treatment effect of renewable energy policies has a significant positive impact on economic growth. Yazdi and Shakouri (2017), using the data from 1979 to 2014 for Iran, examined the relationship between economic growth, renewable energy consumption, energy consumption, financial development and trade. According to the results, there was one-way causality from renewable energy consumption to economic growth. Taghvaei et al. (2017), using the data from 1981 to 2012 for Iran, estimated the nexus between economic growth and renewable energy. According to the results, renewable energy consumption was an insignificant driver to economic growth. Governors should promote this kind of energy to assign a large part of total energy consumption to it. Dees and Auktor (2018) estimated that investing in renewables is beneficial for MENA countries, and that this could be an incentive to intensify the existing policy toward renewables in the region. To improve the positive economic impact of growth, policymakers should support local manufacturing and service provision associated with renewable energy sources. Amri (2017a), using the data from 1980 to 2012 for Algeria, investigated the relationship between renewable and non-renewable energy consumption, growth and capital.

According to the findings of this study, there is a one-way relationship from renewable energy consumption to economic growth. Amri (2017b), using the data from 1990 to 2012 for 72 countries, investigated the relationship between renewable energy consumption, growth and foreign trade. The results showed that there was a bi-directional relationship between renewable energy consumption and growth. Bekareva et al. (2017), using the numerical data from 2000 to 2014, investigated the relationship between renewable energy and economic growth. According to the results, for the USA and some other states, renewable energy is an important part of economic growth. Brini et al. (2017), using the data from 1980 to 2011 for Tunisia, examined the relationship between renewable energy consumption, growth, foreign trade and oil prices. According to the study, there is a one-way relationship from renewable energy consumption to growth. Ito (2017), using the data from 2002 to 2011 for 42 developed countries, examined the relationship between renewable energy consumption, growth, non-renewable energy consumption and CO₂ emission. According to the result, there is a one-way relationship from renewable energy consumption to growth. Taher (2017), using the data from 1990 to 2012 for Lebanon, investigated the impact of renewable energy consumption on economic growth. Results showed a statistically significant impact of renewable energy consumption on the Lebanese economic growth. Magazzino (2017), using the data from 1970 to 2007 for Italy, investigated the renewable energy consumption –
economic growth nexus. According to the Toda–Yamamoto results, there was a one-way relationship from renewable energy consumption to aggregate income. Soava et al. (2018), using the data 1995 to 2015 for 28 countries of the EU, investigated the relationship between economic growth and renewable energy consumption. Findings showed that there was a positive impact of renewable energy consumption on economic growth.

The studies that found that economic growth has an effect on renewable energy are given below.

Sadorsky (2009a), using the data from 1994 to 2003 for 18 emerging countries, investigated the relationship between real income per capita and renewable energy consumption per capita. According the findings, real income per capita and renewable energy consumption per capita had a positive effect for emerging economies. There was a one-way causality relationship from growth to energy consumption. Burakov and Freidin (2017), using the data from 1990 to 2014 for Russia, investigated the causal relationship between renewable energy consumption, economic growth and financial development. The results of the Granger causality test show that there was two-way causality between economic growth and financial development. It is also found that renewable energy consumption does not cause Granger causality on economic growth or financial development.

There is also a study that found no causal link between renewable energy consumption and economic growth.

Bélaïd and Youssef (2017), using the data from 1980 to 2012 for Algeria, investigated the relationship between renewable energy consumption, growth, non-renewable energy consumption and CO₂ emission. According to the results of the study, there was no relationship between renewable energy consumption and growth. Ben Jebli and Ben Youssef (2015), using the data from 1980 to 2010 for 69 countries, investigated the relationship between renewable energy consumption, growth, non-renewable energy consumption, labor force, capital and foreign trade. According to the results of the study, there was no relationship between renewable energy consumption and growth. Menegaki (2011), using the data from 1997 to 2007 for 27 European countries, investigated that empirical results do not confirm causality between renewable energy consumption and GDP.

In this study, we aimed to contribute to the literature by analyzing and strategies of Bulgaria by examining the renewable energy–economic growth relationship of the country. At the same time, this study is an example of studies that examine the same subject with similar and same methods.

3. Methodology and data

This study investigates the relationship between renewable energy and economic growth for the Bulgarian economy. Annual data from 1990 to 2016 were obtained from the website of the World Bank. During this period, the democratization of the Balkans and several crisis cycles in Bulgaria were also considered. REC percentage of total final energy consumption, REO percentage of total electricity output and economic growth (GDP constant 2010 US$) were used. Only the natural logarithm of the GDP in constant prices in US dollars is considered in this study. Other variables are based on the ratio of REC percentage of total final energy consumption and REO percentage of total electricity output.

It is important to check whether the series are stationary before examining the long-term relationship in the series. Many unit root tests are available to investigate the stationarity of the series to determine the existence of regression problems. The levels or differences of the variables that are stationary are investigated by augmented Dickey–Fuller (ADF), Philips–Perron (PP) and KPSS unit root tests. However, there might be a structural break in the global finance crisis in the related period. Therefore, the structural fracture unit root test
was also used in the study. The existence of a long-term relationship between variables in the study was explored by the ARDL bound test. In this cointegration test, some variables can be used in level values (I[0]) where some variables are stationary in the first difference (I[1]). In addition to this, other cointegration techniques are sensitive to the periods of the sample. In this approach, the sample periods are not a problem even if they are short (Harris and Sollis, 2003, p. 152).

In this context, Pesaran and Pesaran (1999) firstly investigate the existence of a long-term relationship with the boundary test. We can write an ARDL bound model as follows:

\[
\Delta GDP_t = \delta_0 + \delta_1 GDP_{t-1} + \delta_2 REC_{t-1} + \delta_3 REO_{t-1} + \delta_4 \Delta GDP_t + \delta_5 \Delta REC_t \\
+ \delta_6 \Delta REO_t + \sum_{i=1}^{p-1} \theta_{ai} GDP_{t-i} + \sum_{i=1}^{q-1} \theta_{bi} REC_{t-i} \\
+ \sum_{i=1}^{s-1} \theta_{ci} REO_{t-i} + \epsilon_t
\] (1)

The cointegration relation is made by testing the hypothesis (H0: \( \delta 1 = \delta 2 = \delta 3 = 0 \)). The F statistic is calculated for any significance level that is possible to make a definite interpretation without considering the integration scores of the variables (Pesaran et al., 2001). If the calculated F statistic exceeds the critical value upper limit, the null hypothesis is rejected and it is decided that there is a long-run relationship between the variables; otherwise, there is no long-run relationship between the variables. Furthermore, if the F statistic remains between the upper and lower limits, there is no definite interpretation as to whether a cointegration relation exists between the variables (Balcilar et al. (2014: 455).

In the Toda and Yamamoto (1995) causality analysis, the optimum lags length (k) is determined by Akaike information criteria (AIC) and Schwartz information criteria (SCI) after the maximum integration level (DMAx) of the series is determined using ADF and PP unit root tests. Finally, the VAR model (k + DMAx) is estimated by the number of lags and seemingly unrelated regression method to decide causality relation and direction. The Toda and Yamamoto (1995) equations for the study are as follows:

\[
GDP_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} GDP_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j} GDP_{t-j} + \sum_{i=1}^{k} \beta_{1i} REO_{t-i} \sum_{i=1}^{d_{max}} \beta_{2i} REO_{t-j} \\
+ \sum_{i=1}^{k} \beta_{3i} REC_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{4i} REC_{t-j} + \nu_{1t}
\] (2)

\[
REO_t = \theta_0 + \sum_{i=1}^{k} \theta_{1i} REO_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{2i} REO_{t-j} + \sum_{i=1}^{k} \alpha_{1i} GDP_{t-i} \sum_{j=k+1}^{d_{max}} \alpha_{2i} GDP_{t-j} \\
+ \sum_{i=1}^{k} \alpha_{3i} REC_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{4i} REC_{t-j} + \nu_{2t}
\] (3)
\[ \text{REC}_t = \omega_0 + \sum_{i=1}^{k} \omega_1 \text{REC}_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \omega_2 \text{REC}_{t-j} + \sum_{i=1}^{k} \gamma_3 \text{GDP}_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \gamma_2 \text{GDP}_{t-j} + \sum_{i=1}^{k} \gamma_3 \text{REO}_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \gamma_4 \text{REO}_{t-j} + \nu_{3t} \]

The causality relation and direction Vector Autoregressive (VAR) \((k + d_{\text{max}})\) model is estimated and the first \(k\) of the model coefficients are determined by applying the modified Wald (MWALD) test. In the causality relation, the null hypothesis is that \(k\) independent variables are equal to zero in the group, and the alternative hypothesis is that \(k\) independent variables are not equal to zero as a group. If the MWALD statistic is significant, the null hypothesis is rejected and the alternative hypothesis is accepted. The acceptance of the alternative hypothesis implies that there is a causal relationship from the independent to dependent variables (Dritsaki, 201: 120-129).

4. Empirical analysis results

In the study, first, descriptive statistics related to variables were given. Relevant findings are given in Table I.

According to the results of Table I, it can be said that all variables have normal distribution. To obtain reliable results in the study, the levels/differences of the variables were examined. For this purpose, ADF, PP and KPSS tests were used in this study. The obtained unit root test results are presented in Table II.

According to Table II, ADF, PP and KPSS unit root test results are contradicted. The variable that is stationary according to the KPSS test is not stationary at the level value according to the PP and ADF tests. The conflicting results mean that a structural fracture unit root test is needed. In such a case, it is necessary to use unit root tests that take into account the possibility of breakage. We analyzed with breakpoint tests owing to possible fluctuations in the Bulgarian economy. Perron (1997) used unit root tests to take structural breaks into account, and the results are reported in Table III.

It can be seen from Table III that all variables are stationary in the first difference. Following the unit root analysis, the relationship between the variables in the study was explored by the ARDL boundary test approach.

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>REC</th>
<th>REO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.519012</td>
<td>8.614995</td>
<td>8.170846</td>
</tr>
<tr>
<td>Median</td>
<td>8.448206</td>
<td>8.801903</td>
<td>6.994762</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.937484</td>
<td>18.15702</td>
<td>17.98859</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.183916</td>
<td>1.916849</td>
<td>3.849684</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.279915</td>
<td>5.11492</td>
<td>3.745821</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.216768</td>
<td>0.365714</td>
<td>1.304164</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.343287</td>
<td>2.072275</td>
<td>3.831781</td>
</tr>
<tr>
<td>Jarque–Bera</td>
<td>3.177038</td>
<td>1.511965</td>
<td>8.119842</td>
</tr>
<tr>
<td>Probability</td>
<td>0.204228</td>
<td>0.469549</td>
<td>0.017250</td>
</tr>
<tr>
<td>Observations</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
</tbody>
</table>

Table I. Descriptive stats
In this test, the appropriate number of lags must first be determined for an unrestricted error correction model. The diagnostic assumptions were taken into account when determining the appropriate number of lags. In this context, no autocorrelation or heteroscedasticity problem is detected. The appropriate number of lags provided by the normal distribution assumption is 1. The findings are reported in Table IV.

To be able to decide the existence of a long-term relationship between the variables, the results in Table IV need to be compared with the critical values of Pesaran and Pesaran (1997). Critical values are given in Table IV. It can be argued that there is no long-run relationship between the variables because the F statistic value in the study is below the critical values for 1, 5 and 10 per cent significance levels. In short, there is no long-term relationship between REC, REO and GDP. There are studies that find similar results (Bélaïd and Youssef, 2017; Ben Jebli and Ben Youssef (2015; Menegaki, 2011).

Finally, the existence of causal link between variables is investigated using the Toda–Yamamoto causality test. The results obtained are reported in Table V. Time graphs related to these variables are also given in the study. The notation is in Figure 1.

As shown in Table V, three different results were obtained in the study. The findings show that REC and REO are the causes of GDP. When this result is evaluated together with

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**Table II.** ADF, PP and KPSS unit root tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>REC</td>
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<td>REO</td>
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</tbody>
</table>

Notes: Critical value at 0.05 significant level in KPSS test is 0.4630 for unit root test with constant term and 0.1180 for unit root test with constant term and trend. The symbols *, ** and *** denote significance at 0.10, 0.05 and 0.01 levels, respectively

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**Table III.** Perron (1997) Breakpoint unit root test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model A</th>
<th>Breakpoint</th>
<th>Model B</th>
<th>Breakpoint</th>
<th>Model C</th>
<th>Breakpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td></td>
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<tr>
<td>REC</td>
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<tr>
<td>REO</td>
<td></td>
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</tr>
</tbody>
</table>

Notes: The symbols *, ** and *** denote significance at 0.10, 0.05 and 0.01 levels, respectively
Figure 1, it should be emphasized that REC and REO increase more than GDP. This result shows that in the Bulgarian economy, renewable energy and electricity output are expected to have a positive impact on economic growth. It is obviously aimed at increasing the economic growth of countries by investing in renewable energy sources in developed countries. According to these findings, it can be said that for the Bulgarian economy, policymakers must invest in renewable energy sources. As seen in Figure 1, the use of renewable energy and the increase in the output of renewable electricity are triggering an upward trend on economic growth. The increase in renewable energy consumption leads to an increase in economic growth. It supports the purpose of this work. It can be said that renewable energy policies play an important role in the country’s strategies, and that a large part of the investments should be shaped in this direction.

Another conclusion that should be drawn from this study is that GDP and REO are the causes of REC. It is a fact that the economic growth and renewable electricity output causes energy consumption. The energy consumption of an energy-intensive country is the expected result, and this result is in line with the findings of Wolde-Rufael (2004, 2005, 2006).

<table>
<thead>
<tr>
<th>lags</th>
<th>Unrestricted intercept and no trend case</th>
<th>F statistic</th>
<th>t statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>2.4566</td>
<td>-2.3737</td>
</tr>
</tbody>
</table>

Pesaran Critical Value

<table>
<thead>
<tr>
<th>d</th>
<th>I(0)</th>
<th>I(1)</th>
<th>I(0)</th>
<th>I(1)</th>
<th>I(0)</th>
<th>I(1)</th>
</tr>
</thead>
</table>

Notes: Critical boundary values are taken from Table F, Case II, of Pesaran and Pesaran (1997 p. 478); d is independent variable number.

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>MWald statistics</th>
<th>Probability value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>REC and REO do not cause GDP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$</td>
<td>2.5331</td>
<td>0.0735*</td>
<td>Rejection</td>
</tr>
<tr>
<td>$H_0: \beta_1 = \beta_2 = 0$</td>
<td>2.4930</td>
<td>0.0763*</td>
<td>Rejection</td>
</tr>
<tr>
<td>$H_0: \beta_3 = \beta_4 = 0$</td>
<td>4.2186</td>
<td>0.0147**</td>
<td>Rejection</td>
</tr>
<tr>
<td>GDP and REC do not cause REO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0: a_1 = a_2 = a_3 = a_4 = 0$</td>
<td>2.3937</td>
<td>0.0911*</td>
<td>Rejection</td>
</tr>
<tr>
<td>$H_0: a_1 = a_2 = 0$</td>
<td>1.9240</td>
<td>0.1765</td>
<td>Acceptance</td>
</tr>
<tr>
<td>$H_0: a_3 = a_4 = 0$</td>
<td>1.5312</td>
<td>0.2446</td>
<td>Acceptance</td>
</tr>
<tr>
<td>GDP and REO do not cause REC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$</td>
<td>3.4305</td>
<td>0.0314**</td>
<td>Rejection</td>
</tr>
<tr>
<td>$H_0: \gamma_1 = \gamma_2 = 0$</td>
<td>3.8121</td>
<td>0.0429**</td>
<td>Rejection</td>
</tr>
<tr>
<td>$H_0: \gamma_3 = \gamma_4 = 0$</td>
<td>4.9921</td>
<td>0.0197**</td>
<td>Rejection</td>
</tr>
</tbody>
</table>

Notes: Jarque–Bera test: 0.7566 Breusch–Godfrey LM test: 2.7455 ** Breusch–Pagan Godfrey test: 1.6704; Jarque–Bera test: 2.7199 Breusch–Godfrey LM test: 1.2976 Breusch–Pagan Godfrey test: 1.1981; Jarque–Bera test: 0.4987 Breusch–Godfrey LM test: 1.1950 Breusch–Pagan Godfrey test: 1.8010; The symbols *, ** and *** denote significance at 0.10, 0.05 and 0.01 levels, respectively.
2009), Lee (2006) and Squalli (2007). Thus, the country can increase its income by setting its own taxation and tariffs in this direction. This revenue can be transferred to another project in need.

The last result is the study that GDP and REC are not the causes of REO. As can be seen in Figure 1, the consumption of renewable energy in the Bulgarian economy has increased in the past decade. The subject matter obtained in the study should be evaluated in this direction. In summary, the results indicate that investment in renewable energy sources in the Bulgarian economy should be increased.

According to the findings in the study, renewable energy sources contribute to sustainable economic growth, environmental sustainability, access to basic services, improvement in human health and income generation activities and provision economic benefits such as new jobs and industries (IRENA, 2016). It is estimated that policy preferences for renewables will create an environmental and economic benefit that will eliminate the ineffective subsidies that support the development and consumption of fossil fuels (O'Sullivan et al., 2017).

5. Conclusion
Considering that Bulgaria is a country dependent on fuels and natural gas, it can be said that the contribution of the alternatives provided by renewable resources is quite significant. In the future, if the cost of establishing renewable energy and its accessibility and cost are competitive with fossil energy sources, it is foreseen that economic developments will take place in a positive way. According to the results obtained, it can be said that the country needs to increase renewable energy resource investments to strengthen long-term relationships between the variables. In this context, it can be said that the effect of renewable energy consumption on economic growth will increase if the country’s strategies and investment incentives are continued and increased. The harmonization laws, incentive premiums and applications for increasing renewable energy investments can have a positive impact on the country’s economy by contributing to the energy supply security of the country. The investments to be made in the field of renewable energy provide significant support for economic growth and development by ensuring positive externality of these investments to increase domestic production, create more jobs and reduce import payments. Additionally, it is estimated that with the increase in employment and employment opportunities, the aging population and immigration rate will
decrease as the economy grows with sustainable renewable energy. Energy supply should be directed to renewable energy sources instead of being dependent on imported fossil fuels. The role of state supporters in this direction is huge. However, it is not possible to mention that the incentives in practice are sufficient. According to the results of the study, incentives should be increased. Particularly, the possibility of access to long-term and low-cost loans and the promotion of industry can be among the solution politics. Attractive credits and incentives are crucial for an investor who is willing to direct current resources and capital to renewable energy investments.

Given the competition of renewable energy investments with fossil fuels, the current fossil fuel incentives are affecting the market in a negative way. This makes renewable energy costlier. These fossil energy incentives prevent the development of renewable energy. In addition, fossil fuel incentives prevent the formation of public support for clean energy. In this context, fossil fuel incentives for Bulgaria should not be applied in the midterm.

As a result, we can say that the incentives provided in the field of renewable energy in Bulgaria are limited when compared with world examples. Additional measures need to be taken to increase the share of renewable energy investments in Bulgaria’s energy production portfolio faster and more efficiently.

References


Further reading


**Corresponding author**

Hamit Can can be contacted at: hamitcan88@hotmail.com

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