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Professional paper

THE IMPORTANCE OF RENEWABLE ENERGY IN THE ECONOMIC DEVELOPMENT OF COUNTRY

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Abstract

Each stage of economic development has been accompanied by a characteristic energy transition, moving from one fuel source to another, as the main factor of energy production growth in developing economies. While the energy demand continues to increase everywhere in the world, the levels of carbon dioxide emitted into the atmosphere have also been increasing, which is negatively affecting efforts to combat climate change. Consumption of non-renewable energy can boost economic growth, but it is undoubtedly a significant source of environmental pollution and carbon dioxide emission.
The paper was implemented via dynamic panel data estimation methods, to research the long-term relationship between renewable energy consumption and economic growth. The study has concluded that there is a long-term balance relationship between renewable energy consumption and economic growth and the empirical results suggest that renewable energy consumption has a positive impact on economic growth.

Keywords: Economic Growth, CEE countries, Long-term relationship, Renewable Energy.

Introduction

In recent years, climate change and global warming, limited reserves of natural gas and petrol sources, high and volatile energy prices, and technological change make it mandatory to replace traditional energy sources with alternative energy sources. Studies have shown that fossil fuel consumption is the largest contributor to global greenhouse gas emissions and that continued dependence on fossil fuels will only exacerbate the rate of environmental degradation. In this context, this study aims to explore and evaluate the relationship between renewable energy consumption and economic growth for 19 Central Eastern European countries, from the time interval 2000-2019, within the framework of a traditional production function. Since the pollution caused by fossil fuels has increased year by year and the economic situation has been worsening due to the COVID-19 and energy crisis, many countries have been forced to find alternative energy sources to conventional energy sources. With the aim of sustainable development for the future, most of them have started investing in new energy developments. Renewable energy sources as an alternative source present themself with an important potential and perform a crucial role, by decreasing dependency on fossil fuels, which are very limited in supply. Due to climate change and the global warming situation, renewable energy could be the most attractive alternative to fossil fuels, reducing the CO2 emission process (Bhuiyan et al., 2022).

The relationship between renewable energy and economic growth has created a large interest among researchers and policymakers worldwide. This interest has also been the motivation for our work and has led us to undertake this study. This study aims to explore the relationship between renewable energy consumption and economic growth for the time interval 2000-2019, for 19 Central Eastern European countries: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, North Macedonia, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, and Ukraine.

Most of the previous studies have shown a positive relationship between renewable energy consumption and economic growth, which is also called the growth hypothesis in literature. Bilgili and Ozturk (2015) found that renewable energy had a significant positive impact on economic growth in G7 and 51 sub-Saharan African countries using panel co-integration, panel OLS and panel DOLS for the 1980–2009 period. Inglesi-Lotz (2016) estimated the impact of renewable energy consumption on economic welfare by employing panel data techniques, including 34 OECD countries for the period from 1990 to 2010, and concluded that the influence of renewable energy consumption on economic growth is positive and statistically significant. Similarly, Koçak and Şarkgüneşi (2017) explored the relationship between renewable energy consumption and economic growth within the framework of the traditional production function for the period of 1990–2012 in 9 Black Sea and Balkan Countries and concluded that there exists a long-term balance relationship between renewable energy consumption and economic growth and renewable energy consumption has a positive impact on economic growth.

Some other studies have shown different results, supporting the neutrality hypothesis (energy consumption doesn't have any effect on economic growth). Menegaki (2011) analyzed the relationship between economic growth and renewable energy for 27 European countries in a multivariate panel framework over the period 1997–2007 using a random effect model and he couldn't find a significant relationship between renewable energy and economic growth. Bhattacharya et al. (2016) in their study examined the possible effect on the economic growth of renewable versus non-renewable energy sources across 38 countries for the time period between 1991 and 2012 and concluded that renewable energy consumption has a positive impact on economic growth for 23 countries and a negative impact for 4 countries. This implies that those countries which had a negative impact on economic growth, need to increase capital for sustainable development of renewable energy consumption and follow a gradual process for deployment. Shahbaz et al. (2020) also examined the effect of renewable energy consumption on economic growth across 38 countries from 1990 to 2018 using DOLS, FMOLS, and heterogeneous non-causality approaches and confirmed the presence of a long-run relationship between renewable energy consumption and economic growth. They also found a positive impact of renewable energy on economic growth for 58% of the sample countries and a negative impact for 24% of the sample countries.

The organization of this paper is as follows: Section 2 discusses the model, data and describes the econometric methodology. Section 3 provides the estimation results, derived from the panel unit root test, the panel cointegration test, as well as the estimation of the long-run coefficients using the DOLS and FMOLS methods. Finally, Section 4 evaluates the main conclusions of our study and policy implications.

Material and Method

In this paper, the linkages between renewable energy and economic growth will be examined using the neo-classical production function following Koçak and Şarkgüneşi (2017). The general type of production function that considers renewable energy, capital, and labor as individual inputs is defined as follows:

$$Y_{it} = f(RE_{it}, K_{it}, L_{it},) \quad (1)$$

In Eq. (1), Y stands for economic growth, RE stands for renewable energy, K stands for capital stock and L stands for labor, while i and t stand for nation and time. Thus, Equation 1 was transformed into a log-linear specification by taking all the variable's natural logarithms. The benefits we get from transforming the equation into logarithmic form are: a) the transformation of the variables into a natural logarithm provides efficient and consistent empirical results (Shahbaz et al., 2012); b) the transformation of data series into a natural logarithm avoids the problems associated with dynamic properties of the data series (Bhattacharya et al., 2016). The empirical equation of the production function is modeled as follows:

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

where β_1, β_2 and β_3 are elasticities of economic growth with respect to renewable energy consumption (RE), capital (K) and labor (L), respectively and ε is the error term.

Our study employs data for 19 Central Eastern European countries (Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, North Macedonia, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, and Ukraine) for the time period 2000-2019. For economic growth, we used GDP (constant 2015 US$), for renewable energy consumption (RE) the share of renewable energy in total final energy consumption (%), for capital (K) we used gross fixed capital formation (constant 2015 US$), and for labor (L) we used labor force participation rate (% of the total population for ages 15-64). All the data that we are using for our study is collected from the World Bank Database.

To study the long-term relationship between renewable energy consumption and economic growth in CEE Countries, we will use the panel data method. First, to test for the stability of the series and to ensure the robustness of our components we will use the panel unit root test. This test considers both heterogeneity and cross-sectional dependence across panels. The first generation of tests assumes that cross-section units are cross-sectionally independent; whereas the second generation of panel unit root tests relaxes this assumption and allows for cross-sectional dependence (Tugcu, 2018). Therefore, the empirical equation of the unit root test is modeled as follows:

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

In equation (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 (Koçak and Şarkgüneşi, 2017). We test the null hypothesis that each series in the panel dataset contains a unit root against the alternative, at least one of the individual series in the panel is stationary (no unit root) H_0: $\rho=0$ and H_a: $\rho < 0$. When the null hypothesis is rejected, it is determined that the series doesn't contain a unit root, so the series are stationary. If the results of the test show that the series are stable at level value, then the analysis will proceed with the traditional OLS method estimation, otherwise, if the series are stable at first differences, the panel cointegration test will be followed in our study.

Second, we use the Pedroni panel cointegration test, to examine if between variables exists a long-term cointegration relationship. Pedroni (2000) introduced seven test statistics that test the null hypothesis of no cointegration (in other words, the residuals are non-stationary) against the alternative hypothesis that approves there is a co-integration relationship. The seven test statistics are grouped into two categories: group-mean statistics that average the results of individual country test statistics and panel statistics that pool the statistics along the within-dimension (Neal, 2014). The first group of Pedroni's tests consists of panel semi-parametric ν, ρ, and t-statistics which corresponds to the variance ratio, and Phillip-Peron ρ and t-statistics univariate analogues, respectively, and parametric panel ADF t-statistics. The second group consists also of Phillip-Peron ρ and t-statistics and ADF t-statistics, but is computed according to the group-mean principle (Mitić et al., 2017). If the results of the Pedroni test indicate that the null hypothesis is rejected, then it is determined that exists a long-term relationship among the variables.

The last step is estimating the long-run elasticity of output, by using Pedroni's (2000, 2001) Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methods, since these two approaches account for serial correlation and endogeneity that may exist in our model. The equation is modeled as follows:

$$Y_{it} = \delta_{it} + \beta_i X_{it} + \varepsilon_{it} \tag{4}$$

where Y and X indicate the dependent variable and the corresponding vector of independent variables, while i, t, and ε stand for individuals, time, and the error term, under the assumption that there is no dependence between sections that consist of the panel. The DOLS estimator in a panel case can be derived by running the following regression:

$$y_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-Ki}^{Ki} \gamma_{ik} \Delta x_{it-k} + \varepsilon_{it} \tag{5}$$

where K denotes the number of lags/leads chosen using some info criterion and γ_{ik} is the coefficient of a lag or lead of the first differenced variables. The DOLS estimator also has an additional advantage in controlling the endogeneity in the model, as augmentation with the lead and lagged differences of the regressor suppresses the endogenous feedback (Lean & Smyth, 2010). Besides the DOLS method and considering that the properties of our data are first-order integrated, this study will also use the Pedroni (2000) FMOLS approach. FMOLS estimator eliminates the second order bias caused by the endogeneity of the regressors by incorporating the Phillips and Hansen (1990) semi-parametric correction into the OLS estimator.

Results and Discussion

We have applied LLC (Levin, Lin, and Chu) panel unit root tests to GDP, Renewable Energy, Capital and Labor levels and first differences. The results of panel unit root test are provided in Table 1.

Table 1. LLC panel unit root test

Variable	I(1)
GDP	-4.42***
ΔGDP	-5.18***
RE	-1.32
ΔRE	-8.25***
K	-4.00***
ΔK	-8.04***
L	-1.10
ΔL	-5.18***

**** Indicates the rejection of null hypothesis of unit root at 1% significance level.*

As we see, the results of the panel unit root test are mixed, especially for GDP and capital, where the LLC test indicates stationarity in both levels in the first differences, while renewable energy consumption and labor are stable only at the first differences. However, the empirical results reported in Table.1 reveal that the null hypothesis of the panel unit root is rejected for all the variables after the first differencing, indicating that the series are stable at the first difference.

The next step is to examine the co-integration relationship between the variables since a long-term equilibrium relationship is possible to happen. Table 2 shows the findings of the panel co-integration test. According to the test results, out of seven test statistics, only five confirm the presence of a co-integration relationship among lnGDP, lnRE, lnK, and lnL. Therefore, we conclude that a balanced relationship in the long term between renewable energy consumption, capital, and labor seems possible.

Table 2. Pedroni panel co-integration test results

	Statistic	**Probability**
Within dimensions (common AR coefficients)		
Panel v-statistic	-4.439***	0.000
Panel rho-statistic	0.249	0.401
Panel PP-statistic	-3.325***	0.000
Panel ADF-statistic	-3.553***	0.000
Between dimensions (individual AR coefficients)		
Group rho-statistic	1.543*	0.061
Group PP-statistic	-4.740***	0.000
Group ADF-statistic	-4.382***	0.000

*** Indicates the rejection of the null hypothesis of the cointegration test at a 1% significance level.
* Indicates the rejection of the null hypothesis of the cointegration test at a 10% significance level.
Newey-West Bandwidth selection with Bartlett Kernel is used.

The last step is to estimate the long-term output elasticities, using panel dynamic OLS and panel fully modified OLS. The results of the estimation for both methods are presented in Table 3. As we can see, both panel DOLS and panel FMOLS give similar results, for each of the variables, in terms of sign and significance level. For the DOLS results, a 1% increase in renewable energy will increase GDP by 0.16%, while for the FMOLS results, a 1% increase in renewable energy will increase GDP by 0.17% and the coefficients are statistically significant at 1% level. Our findings also suggest that both capital and labor have a positive impact on economic growth, and coefficients are statistically significant at 1% and 5% level, respectively.

Table 3. Panel data analysis for CEE Countries (2000-2019)

Variable	**Panel DOLS**		**Panel FMOLS**	
	Coefficient	t-statistic	Coefficient	t-statistic
lnK	0.488***	0.000	0.536***	0.000
lnL	0.416**	0.022	0.327**	0.021
lnRE	0.163***	0.000	0.170***	0.000

*** Indicates the significance level at 1%.
** Indicates the significance level at 5%.

Conclusions

The purpose of this study is to expand prior research and to determine quantitatively the impact of renewable energy consumption on economic growth, in a panel data framework, including 19 Central East European countries for the time period from 2000 to 2019. This relationship is explored in the frame of a traditional production function, also known as the Cobb-Douglas production function. The data we employed for CEE countries were taken from World Bank Database.

The results of our analysis showed that the series are stationary at the first differences by the panel unit root test and between the variables exists a long-run equilibrium relationship by Pedroni co-integration test. To estimate the parameters of the relationship between renewable energy and economic growth we used panel FMOLS and DOLS methods and concluded that renewable energy can be considered as a significant driver of economic growth. Specifically, the results of this study indicate that a 1% increase in renewable energy consumption will increase GDP by 0.16%.

The findings in this paper suggest that it is very important for government policies to support and promote the use of renewable energy sources in these CEE countries, replacing the use of traditional energy sources. To develop a sustainable economy, all the countries need a wide range of policy interventions and financing measures to support the transformation of energy and to improve energy efficiency. The government could promote innovation, providing fiscal incentives to companies investing in the R&D sector for finding more efficient solutions and clean-energy technologies that could be adopted. Governments could also decide to stimulate the use of renewable energy by lowering taxes, reducing investment costs through subsidies, loans, and grants, or by using sales tax exemptions for solar cells and feed-in tariffs. In those countries where the policies will be adopted, it will not only encourage them to export their technologies, but also lead them to share their policy experiences with other countries, creating renewable energy-oriented networks between their organizations.

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