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Renewable Energy Consumption and Economic Growth Relationship in Developing Countries

Gelişmekte Olan Ülkelerde Yenilenebilir Enerji Tüketimi ve Ekonomik Büyüme İlişkisi*

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ÖZ

Yenilenebilir enerji tipik olarak güneş, rüzgâr, jeotermal, gelgit ve dalga, odun, atık ve biyokütle kaynaklarından üretilen enerji olarak tanımlanmaktadır. Yenilenebilir enerji, çevreye etkisi daha az olan temiz bir enerji kaynağı olması nedeniyle hayati bir konudur. Bu çalışma, gelişmekte olan ülkelerde, 1990-2019 yılları arası yenilenebilir enerji kullanımı ile ekonomik büyüme arasındaki ilişkiyi panel veri analiziyle araştırmayı amaçlamaktadır. Serinin durağanlığı için panel birim kök testi yapılmıştır. Bu aşamadan sonra panel eşbütünleşme testleri yapılmış ve Pedroni testine göre yenilenebilir enerji tüketimi ile ekonomik büyüme arasında uzun dönemli bir ilişki tespit edilmiştir. Nedenselliğin yönü için panel nedensellik testi yapılmış ve test sonuçları ekonomik büyümeden yenilenebilir enerji tüketimine doğru tek yönlü bir ilişki olduğunu göstermiştir. Büyüme yenilenebilir enerji tüketimini artırmakta ve karbon emisyonlarını azaltmaktadır. Nedenselliğin yönü, koruma hipotezinin gelişmekte olan ülkeler için geçerli olduğunu göstermektedir.

Anahtar Kelimeler: *yenilenebilir enerji, ekonomik büyüme, panel nedensellik, panel eşbütünleşme*

ABSTRACT

Renewable energy is typically characterized as energy produced from solar, wind, geothermal, tide and wave, wood, waste, and biomass sources. Renewable energy is a crucial issue since it is a clean energy source with less environmental impact. This study aims to use panel methodologies to investigate the relationship between the use of renewable energy and economic growth in developing countries for the years 1990 to 2019. Panel unit root test was performed for the stationarity of the series. After this stage, panel cointegration tests were performed and a long run relationship for renewable energy consumption and economic growth was detected according to the Pedroni test. For the direction of causality, panel causality test was performed, and test results showed unidirectional relationship from economic growth to renewable energy consumption. Growth increases renewable energy consumption and reduces carbon emissions. The direction of causality suggests that conservation hypothesis is valid for developing countries.

Keywords: *renewable energy, economic growth, panel causality, panel cointegration*

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INTRODUCTION

Climate change has become a major concern for developing nations due to the threat it poses to energy and food independence, as well as to overall productivity (Acevedo-Ramos et al., 2023: 2). Utilizing energy resources efficiently is essential for economic growth (EG) and sustainability. However, excessive use of fossil fuels hinders sustainable EG, and the emissions emitted have negative effects on the environment (Madaleno et al., 2023: 1).

As a result of the environmental effects of global warming and greenhouse gas emissions, concerns regarding the consumption of fossil fuels have increased, and renewable energy (RE) sources have become a significant portion of the global energy consumption (EC). RE sources are distinguished by their capacity to reduce carbon dioxide emissions (CO2) and contribute to environmental protection. Theoretically, fossil fuels are believed to be able to regenerate themselves for a very long period, yet they face extinction (Ocal & Aslan 2013: 494).

Typically, RE is defined as energy derived from solar, wind, geothermal, tide and wave, wood, refuse, and biomass sources. RE, in contrast to traditional energy, is clean, safe, and infinite. As a result, it is expanding rapidly around the globe and, according to forecasts, will surpass many conventional energy sources to become the leading source of EC. Energy insufficiency affects all aspects of development, including social, economic, environmental, and even life quality. Standard of living enhancements are reflected in higher agricultural output, greater industrial output, the provision of efficient transportation, suitable accommodation, healthcare, and other human services, all of which will need an increase in total EC. Consequently, energy is regarded as a crucial prerequisite for economic progress and a potential element impeding economic and social development (Apergis & Danuletiu, 2014: 578).

Many countries take precautions and sign agreements for environmental sensitivity. The Kyoto Protocol, for example, is an agreement that aims to combat global warming and climate change. In developed countries, environmental sensitivity has increased with RE concept. In this context, various concepts have emerged in energy economics literature. Green GDP is a measure of EG that considers environmental problems like depletion of natural resources (Stjepanovi´c et al., 2017: 575).

The concepts of environmental pollution, EG, RE, which occur as a result of global warming and climate change, are related to each other. The relationship between environmental pollution and EG can be shown by Environmental Kuznets Curve (EKC). According to the EKC, while per capita income increases, environmental pollution increases first and then (after reaching a certain income level) environmental pollution decreases with increasing per capita income.

The orientations of the causal relationship between RE consumption (REC) and EG are characterized by four hypotheses: The growth hypothesis suggests a unidirectional causal relationship between REC and EG. In this situation, the economy is energy-dependent, and energy conservation policies may hinder EG. According to the conservation hypothesis, economic development causes the REC. The impact of energy conservation policies on EG may be minimal or nonexistent. The hypothesis of bidirectional causality between these variables is known as the feedback hypothesis. It implies interdependence and prospective complementarities between EG and EC. According to the neutrality hypothesis, there is no causal relationship. Therefore, energy conservation policies will have a negligible impact on EG (Apergis & Danuletiu, 2014: 579).

This study aims to use panel methodologies to investigate the relationship between REC and EG in developing countries for the years 1990 to 2019. The remainder of the study is structured as follows: The summary of the previous studies is provided in Section 2. The data, econometric application, and findings are presented in Section 3. Conclusions are provided in Section 4.

LITERATURE

In the literature, there are a number of studies investigating the relationship between REC and EG. Some of the literature reviews are presented below.

The REC has a negative impact on EG, according to Ocal and Aslan (2013). In addition, the relationship between EG and REC is unidirectional. Both Apergis and Danuletiu (2014) and Fotourehchi (2017) identify a unidirectional causal relationship between RE and GDP. Saidi and Mbarek (2016) demonstrate a causal relationship in one direction between REC and per capita GDP. Ito (2017) investigates the relationship between non-renewable and RE and economic development. Long-term, non-REC has a negative impact on economic development in developing countries, whereas REC contributes positively to EG. The study by Destek and Aslan (2017) supports the growth, conservation, feedback, and neutrality hypotheses. Ozcan & Ozturk (2019) claim that the neutrality hypothesis is valid. Namahoro et al. (2021) identify a unidirectional causal relationship between the REC and economic development. Wang et al. (2021) identify a unidirectional causal relationship between economic development and REC, with EG stimulating REC. According to Chakraborty and Mazzanti (2021), per capita EG increases electricity consumption and electricity consumption derived from fossil fuels. Fareed & Pata (2022) show that growth and conservation hypotheses are valid. In the study of Mounir & Hind (2022) conservative, growth and neutrality hypotheses are supported. Gyimah et al. (2022) detect feedback hypothesis.

In the literature, there are studies that deal with carbon dioxide emissions (CO2), EC and EG together. According to Farhani and Rejeb (2012), there is no short-term causal relationship between GDP and EC or CO2 and EC. Long-term causality from GDP and CO2 to EC is unidirectional. Salahuddin and Khan (2013) identify a bidirectional relationship between EC and economic development, but they are unable to identify a causal relationship between CO2 and EG. According to Alshehry and Belloumi's (2015) research, there is a unidirectional causal relationship between EC, EG and CO2, and a bidirectional causal relationship between CO2 and EG. Short-term causality is unidirectional between CO2 and EC, and between economic output, energy price and CO2. Ozcag (2019) identifies a unidirectional relationship between per capita GDP and per capita CO2 in Brazil and Indonesia, a bidirectional relationship in India, and a unidirectional relationship between per capita CO2 and per capita GDP in Türkiye and South Africa. Torun et al. (2022) find a unidirectional relationship from GDP to CO2 and a unidirectional relationship from CO2 to GDP. Mitic et al. (2023) finds a bidirectional causal relationship between GDP and CO2. Narayan & Narayan (2010) and Onofrei et al. (2022) detect cointegration relationship. For other studies, Bengochea- Morancho et al. (2001), Halicioglu (2009), Acaravci & Ozturk (2010), Shahbaz et al. (2013), Magazzino (2015), Dogan & Seker (2016), Jiang & Guan (2016), Cosmas et al. (2019), Toumi & Toumi (2019), Bilan et al. (2019), Breed et al. (2021), Azam et al. (2021), Baz et al. (2021), Favero et al. (2022), Khan et al. (2022), Tagwi (2022) can be seen.

Some studies on this subject are related to the EKC. While Dinda et al. (2000), Perman & Stern (2003) and Lacheheb et al. (2015) find no evidence, Canas et al. (2003) and Galeotti et al. (2006) find evidence for it. Azomahou et al. (2006) find some evidence.

METHOD AND APPLICATION

Annual data from 1990 to 2019 for the countries studied[2] was provided by World Data Bank[3]. The dependent variable (EG) is represented by GDP per capita constant 2015 US$ and the independent variable (RE) is represented by REC (% of total final energy consumption).

[2] Türkiye, Brazil, China, South Africa, Russia, Mexico, Malaysia, India

[3] https://data.worldbank.org/

In the first stage of the application, it will be investigated whether there is a correlation between the cross-section dependence of the series, that is, the error terms of each unit. Equation (1) shows the cross-section dependence between the error terms. If there is cross-section dependency, second generation panel unit root tests are used, if not, first generation panel unit root tests are used.

$$\begin{matrix} H_0 : \text{cov}(u_{it}, u_{jt}) = 0 \\ H_1 : \text{cov}(u_{it}, u_{jt}) \neq 0 \end{matrix} \quad i \neq j \qquad (1)$$

According to Pesaran (2004), the null hypothesis shows that there is no cross-section dependence, while the alternative hypothesis shows that there is a cross-section dependence.

The regression for Pesaran (2003) panel unit root test is shown in equation (2):

$$\Delta Y_{it} = a_i + b_i Y_{i,t-1} + c_i \overline{Y}_{t-1} + d_i \Delta \overline{Y}_t + e_{i,t} \qquad (2)$$

Cross-sectional dependence test results are shown below.

Table 1. Pesaran CD Cross Sectional Dependency Test

Variables	Probability Value
RE	0.000
EG	0.000

The null hypothesis stating that there is no cross-section dependence was rejected at the 1%, 5% and 10% significance levels. So, second generation panel unit root tests will be applied due to the cross-section dependency.

Panel unit root test results are shown below.

Table 2. Pesaran Panel Unit Root Test

Variables	Probability Value
RE (2)	0.070
EG (2)	0.490
ΔRE (2)	0.000
ΔEG (2)	0.003

The values in parentheses show lag lenght.

The applied panel unit root test shows that all variables are not stationary at the 1% and 5% significance levels but become stationary when first-order differences are taken. Since the variables are integrated of the same order, the cointegration relationship can be investigated.

Kao (1999) developed the residual cointegration method in panel data. In this method, Dickey Fuller and Extended Dickey Fuller tests are used. After the model is estimated, it is investigated whether there is a unit root in the residues. The ADF test statistic in equation (3) is used in this method because it takes into account the autocorrelation problem. This test statistic is normally distributed with 0 mean and 1 variance.

$$ADF = \frac{t_{ADF} + \sqrt{6N}\hat{\sigma}_v / 2\hat{\sigma}_{0u}}{\sqrt{\hat{\sigma}_{0v}^2 / 2\hat{\sigma}_v^2 + 3\hat{\sigma}_v^2 / 10\hat{\sigma}_{0v}^2}} \quad (3)$$

Pedroni (1999) presented a method for testing the null hypothesis of no cointegration in dynamic panels with multiple regressors and estimate the critical values for these tests. Pedroni (1999) developed seven test statistics to examine the long-run relationship. Four of them are called in-group and three are called inter-group test statistics.

Table 3 and Table 4 summarize cointegration test results.

Table 3. Kao Cointegration Test

Dependent Variable: EG	Probability Value
	0.2733

Table 4. Pedroni Cointegration Test

Dependent Variable: EG	Probability Value
Panel v	0.8226
Panel rho	0.0000
Panel pp	0.0000
Panel ADF	0.0001
Group rho	0.0000
Group PP	0.0000
Group ADF	0.0008

As can be seen from Table 3, Kao cointegration test cannot reject the null of no cointegration. However, except Panel v statistics, all statistics in the Pedroni test (Table 4) can reject the null hypothesis at 1%, 5% and 10% significance levels.

For the direction of causality, causality test was performed, and test results are summarized at Table 5.

Table 5. Panel Causality Test

Causality Directions	Probability Value
RE→EG	0.2246
EG→ RE	**0.0108**

Causality test shows that there is a unidirectional causality running from EG to REC at 1%, 5% and 10% significance level, respectively. This result is consistent with Ocal & Aslan (2013), Destek & Aslan

(2017), Wang et al. (2021), Chakraborty & Mazzanti (2021), Fareed & Pata (2022), Mounir & Hind (2022).

CONCLUSION

In the contemporary world, global warming and climate change have emerged as significant concerns. One of the most significant empirical relationships investigated in the field of ecological economics is the correlation between pollution and economic development. The significance of this has increased since the early 1990s, when concerns emerged regarding climate change, specifically global warming caused by deteriorating environmental quality. Significant carbon dioxide emissions are considered the principal driver of global warming. As an international endeavor to combat climate change, the transition to a low-carbon economy has emerged as a leading concern for governments. Regardless of other strategic objectives, CO2 emissions can be effectively reduced through the reduction of high-emission sectors and the expansion of low-emission industries. While preserving EG and prosperity, it is possible to achieve the urgent goal of reducing CO2. Hence, a meticulously planned industrial strategy has the potential to influence various aspects of a country's economy and competitiveness, including employment and environmental sustainability, CO2 and other greenhouse gas emissions, and productivity.

This study aims to use panel methodologies to investigate the relationship between the use of RE and EG in developing countries for the years 1990 to 2019. A long run relationship for REC and EG was detected according to the Pedroni test. Causality test results showed unidirectional relationship from EG to REC. Among these countries, China and India are the fastest growing countries. Development and wealth increase depending on growth. Growth increases REC and reduces CO2 with carbon footprints. This shows that environmental sensitivity has increased in developing countries.

In developing nations, the results indicate that the conservation hypothesis is valid. Energy conservation policies might not have an adverse effect on EG, according to this hypothesis. Nevertheless, incorrect political implementations of REC may have an adverse impact on growth in developing nations. As income growth has been a significant factor in the increasing use of RE, it is an expensive energy source for developing countries.

Compliance with Ethical Standard

Author contribution: Fatma İdil Baktemur contributed to all stages of preparing, drafting, writing, and revising this research article.

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