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Araştırma Makalesi / Research Article

The Relationship Between Renewable Energy Use and Economic Growth for Energy Importing Emerging Economies

Mustafa Naimoğlu[1]

Abstract

This study examines the relationship between renewable energy use and economic growth for 16 energy-importing countries for the period 1990-2018. These economies have attracted attention in the last 29 years by increasing their use of renewable energy by 556.21%, their total GDP by 466.19% and their total energy imports by 388.96%. Therefore, in this study, the long-term relationship is investigated by using annual data of real GDP, real gross capital, labor, and renewable energy use for 16 energy-importing countries. Firstly, unit root tests are used to determine the stationarity of the series. Then, the cointegration relationship was tested with a heterogeneous panel cointegration test and the cointegration relationship was found. The study found that all of the variables examined had positive and statistically significant coefficients. Additionally, the error correction model used in the study indicated that there is unidirectional causality from economic growth to renewable energy use in both the short and long term. This supports the conservation hypothesis, which suggests that economic growth and renewable energy use are interdependent. Therefore, the study's results suggest that any policies aimed at reducing energy use in these countries will not harm economic growth.

Keywords: *Renewable Energy Use, Growth, Panel Cointegration, Causality, Energy-importing Emerging Economies.*

Enerji İthalatçısı Yükselen Ekonomilerde Yenilenebilir Enerji Kullanımı ve Ekonomik Büyüme Arasındaki İlişki

Öz

Bu çalışma, 1990-2018 döneminde 16 enerji ithal eden ülke için yenilenebilir enerji kullanımı ile ekonomik büyüme arasındaki ilişkiyi incelemektedir. Bu ekonomiler son 29 yılda yenilenebilir enerji kullanımlarını %556,21, toplam GSYH'lerini %466,19 ve toplam enerji ithalatlarını %388,96 artırarak dikkatleri üzerine çekmiştir. Bu nedenle bu çalışmada enerji ithal eden 16 ülke için yıllık reel GSYİH, reel brüt sermaye, işgücü ve yenilenebilir enerji kullanımı verileri kullanılarak uzun vadeli ilişki araştırılmaktadır. Serilerin durağanlığını belirlemek için öncelikle birim kök testleri kullanılmaktadır. Daha sonra eşbütünleşme ilişkisi heterojen panel eşbütünleşme testi ile test edilmiş ve eşbütünleşme ilişkisi bulunmuştur. Çalışma, incelenen tüm değişkenlerin pozitif ve istatistiksel olarak anlamlı katsayılara sahip olduğunu bulmuştur. Ayrıca çalışmada kullanılan hata düzeltme modeli hem kısa hem de uzun dönemde ekonomik büyümeden yenilenebilir enerji kullanımına doğru tek yönlü bir nedensellik olduğunu göstermiştir. Bu, ekonomik büyüme ve yenilenebilir enerji kullanımının birbirine bağlı olduğunu öne süren koruma hipotezini desteklemektedir. Dolayısıyla çalışmanın sonuçları, bu ülkelerde enerji kullanımını azaltmaya yönelik herhangi bir politikanın ekonomik büyümeye zarar vermeyeceğini göstermektedir.

Anahtar Kelimeler: *Yenilenebilir Enerji Kullanımı, Büyüme, Panel Eşbütünleşme, Nedensellik, Enerji ithalatçısı Yükselen Ekonomiler.*

[1] Ph.D., Bingöl University, Department of Economics, mnaimoglu@bingol.edu.tr, https://orcid.org/0000-0001-9684-159X

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INTRODUCTION

According to the calculations made by us with the data obtained from International Energy Agency (IEA), the world fossil fuel consumption rate increased by 1.59% annually (coal by 1.97%, oil by 1.19%, and natural gas by 2.44%) in the 1990-2018 period. However, the world's renewable energy usage rate has become the fastest-growing energy source in the world with an annual average increase of 3.93% (hydro 2.45%, wind, solar, etc. 7.63%) in the same period. In the energy importing emerging economies, which are the subject of the study, fossil fuel has an annual average increase rate of 3.90% (coal 4.12%, oil 3.51%, and natural gas 3.77%). However, the use of renewable energy, on the other hand, became the fastest-growing energy source in the world as well as in emerging energy importing economies, with an annual average increase rate of 6.95% (hydro 5.74%, wind, solar, etc. 9.12%) in the same period. Therefore, emerging energy importing economies have a higher rate of increase in fossil fuel and renewable energy use than the world average. According to the World Bank (2021), world GDP increased by an average of 2.83% annually from 1990-2018. However, this increase is 6.39% in energy-importing emerging economies. Consequently, emerging energy-importing economies are the locomotive of the global economy with their high growth rates. This growth was again realized by energy use, which has a higher share than the world average growth rate.

In energy importing emerging economies, energy imports for the period 1990-2018 have an annual average rate of increase of 5.83%. The fact that these imports are generally realized as fossil fuels cause an annual energy loss of 2.99% for the same period in these economies that do not have enough technology in the field of energy. Furthermore, the inability to determine the optimal installed capacity allocation of renewable energy resources in economies causes avoidance of these resources due to this installation cost (Behboodi et al., 2016). Moreover, in the same period, while CO_2 emissions in the world had an average increase rate of 1.77%, energy importing countries were also the locomotive of global pollution with an increase of 4.07%. Consequently, the economic growth experienced in these economies results in more energy imports, more fossil fuel use, more energy losses, and more CO_2 emissions. In addition, increasing economic growth in these economies results in more energy imports, more energy costs, more foreign exchange needs, more current account deficit, and more foreign dependency. That is why the use of renewable energy for emerging energy importing economies will not only reduce foreign dependency in the field of energy but also increase environmental quality (Akal, 2016b). The increase in the use of green energy in these economies is expected to have a significant positive impact on the global environmental quality (Chatzizacharia et al., 2015). Hence, this study aims to understand the effect of green energy use on GDP increases in 16 energy importing emerging economies with current period data.

This study is an issue that will always stay up to date in the world/especially in developing energy-importing economies. (According to the International Energy Agency [IEA], 2021), the world's share of total fossil fuel use in 2018 is quite high, at 81% (31.49% oil, 26.88% coal, and 22.84% natural gas). The share of renewable energy is very low, 4.54% (hydro 2.54%, excluding hydro 2.01%). Besides, considering the negative effects of fossil fuel use on the environment, the temperature change in the world increased by 131.6% in 2019 compared to 1990 (The Food and Agriculture Organization of the United Nations Statistics [FAOSTAT], 2021). These increases in temperature changes threaten hydro resources, which have a 55.84% share among the world's renewable energy resources in 2018 (IEA, 2021). On the other hand, increasing temperatures create drought and cause forest fires. The amount of water used in the fight against these fires also seriously threatens the hydro energy source. Furthermore, the increase in temperature changes causes more cooling to be used in buildings and vehicles. This situation causes more energy demand and more fossil fuel use. Moreover, while 2 billion tons of CO2 gas emissions were realized in the world in the early 1900s, 36.2 billion tons of gas were released in 2018 with an increase of approximately 1600% (Gurler et al., 2020). F, a 43.83% increase in the world population in 2018 compared to 1990 will further increase the need for energy (World Bank, 2021). Besides all these negativities, the fact that fossil fuel reserves have 51 years of life left in the oil, 53 years in natural gas, and 114 years in coal (Enerji ve Tabii Kaynaklar Bakanlığı [ETBK], 2017), and despite today's technologies, the efficiency experienced in oil, coal, gas, biomass, nuclear and renewable energy inputs have been increased. However, the fact that it has a very low rate of around 11% increases the importance of renewable energy use for all countries in the world. Hence, all these bad scenarios not only threaten the future of a livable world but also show that there are very important opportunities to be evaluated. Consequently, the use of green energy offers very important opportunities. However, with the use of renewable energy, it becomes very important to use it efficiently (Akal, 2016a; Akal, 2016b; Gurler et al., 2020). Besides, it will be very important to improve the environmental conditions for the transmission, transportation, and storage of energy.

Increasing economic growth is still driven by a high percentage of fossil fuels. Despite the decrease in fossil fuel reserve life, the fact that the share of fossil fuel use is still at very high levels is a worrying situation, especially for energy importing economies. Hence, it becomes very important to understand the relationship between economic growth and green energy use in the discussion of a sustainable, reliable, and clean energy future for the high CO2 emissions and deteriorating environmental quality resulting from the use of highly used non-renewable. The difference of this study from previous studies is that energy importing economies are the primary addressees of renewable energy use. Secondly, the high growth figures of emerging economies with high energy use and high non-renewable energy use make the impact of renewable energy use on economic growth very important for energy importing countries among emerging economies. Third, in the study, a production model is used by including capital and labor variables in addition to renewable energy. Fourth, the results obtained are by the theoretical expectation and are supported by hypotheses. Fifth, a panel cointegration test will be used, which allows heterogeneity by combining time-series and cross-section data.

The following section focuses on the literature review on the causal relationship between renewable energy use and economic growth. In the third chapter, the data used in the study are introduced and the methodology to be used is discussed. In the last section, the findings obtained from the study are presented. Finally, in the light of the findings, it ends with policy recommendations in the world/especially for energy-importing emerging economies.

1. OVERVIEW OF THE LITERATURE WITHIN THE FRAMEWORK OF ENERGY USE AND GROWTH HYPOTHESES

In the literature, the number of studies on renewable energy has increased recently. Based on these studies, the causality relationship related to the effect of energy use on economic growth is based on four basic hypotheses. These are growth, conservation, feedback, and neutrality hypotheses (Apergis and Payne, 2009; Apergis and Payne, 2011; Bilgili and Ozturk, 2015, Taskin et al., 2020).

The Growth Hypothesis is the situation where energy use affects economic growth directly or with a complementary effect on capital and labor. In this case, if there is a unidirectional causality running from renewable energy use to economic growth, then the growth hypothesis is valid. In such a situation, any policy to reduce energy use will harm economic growth. Lee and Chang (2008) found unidirectional causality running from renewable energy use to economic growth in 16 Asian countries. Similarly, Pao and Tsai (2010) for BRICS countries, Tang et al. (2016) for Vietnam, and Inglesi-Lotz (2016) for OECD countries found the validity of the growth hypothesis.

The Conservation Hypothesis is the situation where economic growth determines energy use. In this case, there is a unidirectional causality running from economic growth to energy use. In that case, any savings policy that can be applied to reduce energy use in economies where the conservation hypothesis is valid will not harm economic growth. Joyeux and Ripple (2011) found that there is a unidirectional causality running from economic growth to renewable energy use in 56 developed and developing economies. Similarly, Caraiani et al., (2015) for Romania, Poland, and Turkey, and Alper and Oguz (2016) for the Czech Republic found the validity of the conservation hypothesis.

The feedback hypothesis is that economic growth and energy use mutually affect each other. In this case, there is bidirectional causality between economic growth and energy use. In this case, any policy to reduce energy use will hurt economic growth. On the other hand, any negative impact on economic growth will adversely affect energy use. In the study conducted by Ohler and Fetters (2014) for OECD countries, it was found that there is bidirectional causality between economic growth and renewable energy use. Similarly, Sbia et al. (2014) found that the Feedback hypothesis is valid for the United Arab Emirates.

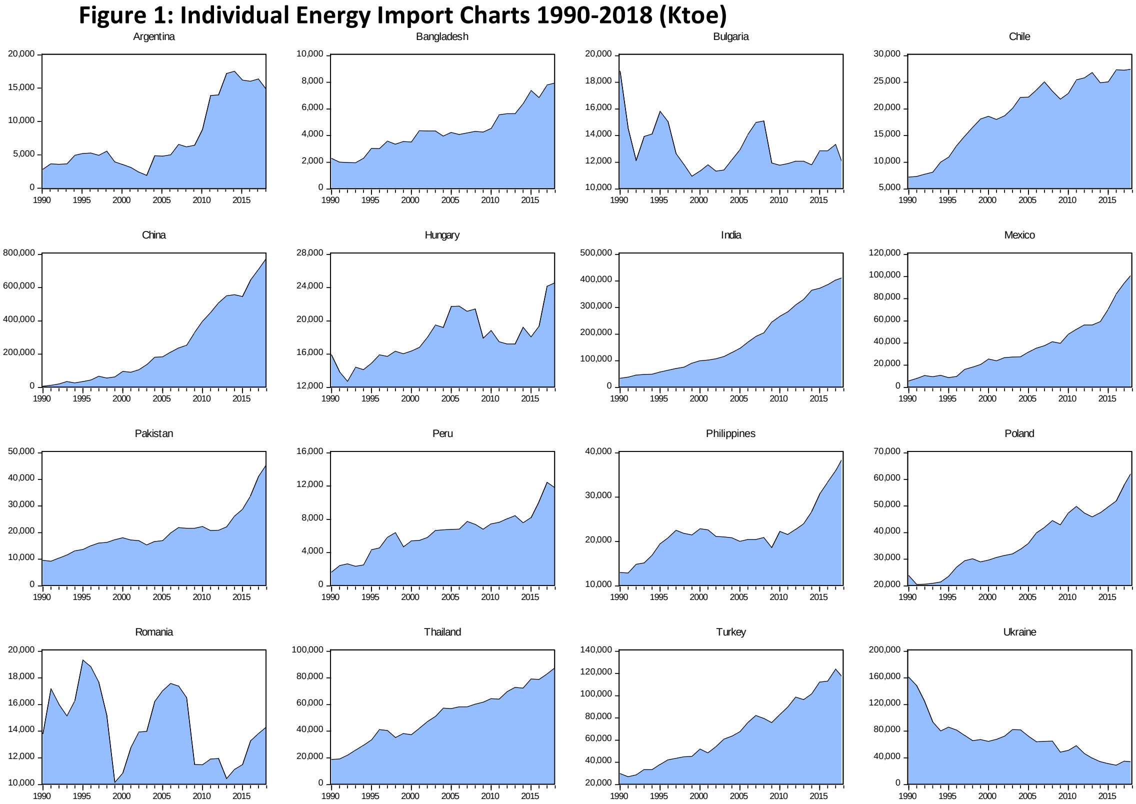
The neutrality hypothesis is the situation where economic growth and energy use are not mutually affected by each other. In this case, there is no causality between energy use and economic growth. Hence, any policy that reduces/increases energy use will not have a negative/positive effect on economic growth. Similarly, any negative impact on economic growth will not affect energy use. Yalta and Jakar (2012) found that there is no causal relationship between economic growth and the use of renewable energy in the study of the Chinese economy. Similarly, Yildirim et al. (2014) for the Next 11 countries found that the Neutrality hypothesis is valid.

With the recent increase in the use of renewable energy, many studies have investigated the relationship between renewable energy use and economic growth. Bhattacharya et al. (2016) researched Panel estimation techniques for 38 countries that consume the most renewable energy. The findings revealed that the use of renewable energy has a significant positive effect on economic growth for 57% of the 38 countries studied. Similarly, Tugcu et al. (2012) investigated the effect of renewable energy and non-renewable energy use on economic growth for G7 countries using the autoregressive distributed lag approach and the Hatemi-j causality test. The findings showed that renewable energy use and non-renewable energy use are important for economic growth in the long run. Apergis and Payne (2010) investigated the effect of renewable energy use on economic growth for OECD countries. According to the empirical results, there is a bidirectional causality between renewable energy use and economic growth in both the short and long term. Similarly, Chen et al. (2020), Ohler and Fetters (2014) for OECD countries in the 1995-2015 period, Ohler and Fetters (2014) for 20 OECD countries in the 1990-2008 period, Lin and Moubarak (2014) and Chang et al. (2015) found that there is a causality between renewable energy use and economic growth for the G7 countries in the 1990-2013 period. Menegaki (2011) researched renewable energy use and economic growth for 27 European countries in the 1997-2007 period. The findings showed that there is no causality between renewable energy use and economic growth. Similarly, Omri et al. (2015) For 17 developed and developing countries in the period 1990-2011, Chang et al. (2015) found that there is no causality between renewable energy use and economic growth for Canada, Italy, and the USA in the 1990-2011 period, and Bulut and Muratoğlu (2018) for Turkey in the 1990-2015 period. On the other hand, Öcal and Aslan (2013) found that the use of renewable energy in the 1990-2010 period harmed Turkey's economic growth. As a result, there is a very large literature in the literature with different results between renewable energy use and economic growth for different country groups in different periods. This study makes important contributions to the literature by focusing on a group of countries that are particularly reliant on energy imports and are important emerging economies. This group of countries is particularly relevant for the study of renewable energy and its impact on economic growth.

2. MODEL AND DATA

The dependent variable in the study is economic growth, and real GDP. So lnGDP=Log (Real GDP (in constant 2010 US dollars)) has been taken. Chart 1 shows the energy import trend of 16 emerging economies, which are energy importers, in the period of 1990-2018[1]. The sensitive, large, and increasing fluctuations in the energy import charts of these economies show how sensitive energy imports are to renewable energy and other factors.

Figure 1: Individual Energy Import Charts 1990-2018 (Ktoe)



Source: International Energy Agency (IEA), (2021).

$$lnGDP_{it} = \beta_{0i} + \beta_{1i} lnREN_{it} + \beta_{2i} lnCPTL_{it} + \beta_{3i} lnLBR_{it} + \varepsilon_{it} \quad (1)$$

$$i = 1, 2, \dots, N \; ; t = 1, 2, \dots, T$$

Where GDP, REN, CPTL and LBR stand for Real GDP, real gross fixed capital formation, labor force and renewable energy use, respectively.

Summary information about the definition of the variables used in the model, data sources, and descriptive statistics are given in Table 1. According to Table 1, serial renewable energy use (lnREN) has the highest standard deviation, while economic growth (lnGDP) has the lowest. The mean values for economic growth (lnGDP) and Real gross fixed capital (lnCPTL) series are close to each other, excluding renewable energy use (lnREN) and Labor force (lnLBR).

Table 1: Definition of Variables and Descriptive Statistics

Variable	Definition	Source	Mean	Std. Dev.	Min.	Max.
lnGDP	Log (Real GDP (constant 2010 US dollars))	World Bank	11.394	0.502	10.482	13.036
$lnREN$	Log (Renewable energy consumtion (power generation from solar PV, solar TH, tide, wind, heat pump, boiler, chemistry heat and others (kilotonnes of oil equivalent (koe)))	International Energy Agency (IEA)	3.194	0.737	1.505	5.265
$lnCPTL$	Log (Real gross fixed capital (constant 2010 US dollars))	World Bank	10.714	0.589	9.027	12.668
$lnLBR$	Log (Labor force (Millions))	World Bank	7.432	0.606	6.514	8.896

3. METHODS AND FINDINGS

In this study, three steps are used to analyze the relationship between renewable energy and economic growth for 16 energy importing emerging economies. First, panel unit root tests, then cointegration, and finally causality tests were used. The reason for using panel data is that it increases the statistical power of the tests by combining information in both cross-section and time dimensions. The method used in this study is similar to that of Apergis and Payne (2010), Agir et al. (2011), and Apergis and Payne (2012).

3.1. Cross-Section Dependency Test

A cross-section dependency test is required to examine the common effects that cannot be observed in the series and to determine the estimation method to be used. In this section, before investigating the stationarity of the variables, a cross-section dependency test will be performed for each series. Performing this test will determine the reliability of the coefficients and standard errors to be obtained. If there is a correlation between units in the series, 2nd generation stationarity tests will be used. Otherwise, 1st generation stationarity tests will be used. In the literature, in cases where T>N, the Breusch-Pagan (1980) CDLM1 test and Pesaran (2004) CDLM2 and Pesaran et. al (2008) CDLM-Adj cross-section dependency tests are used. The null hypothesis of this test is "there is no cross-sectional dependence. ". Consequently, cross-section dependency testing will be performed for all series with CDLM1, CDLM2, and CDLM-Adj tests.

Table 2: Inter-Unit Cross-Section Dependency Test Results Based on Variables

Variable	CD_{LM1}	CD_{LM2}	CD_{LM-adj}
$\mathbf{lnGDP}$	2822.125^{***} (0.000)	174.421^{***} (0.000)	50.304^{***} (0.000)
$\boldsymbol{lnREN}$	1367.894^{***} (0.000)	80.551^{***} (0.000)	30.663^{***} (0.000)
$\boldsymbol{lnCPTL}$	2178.820^{***} (0.000)	132.896^{***} (0.000)	40.368^{***} (0.000)
$\boldsymbol{lnLBR}$	2598.905^{***} (0.000)	160.013^{***} (0.000)	16.796^{***} (0.000)

Note: *** denotes significance at the %1. The expressions in parentheses show probability values.

When Table 2 is examined, it is seen that there is a cross-sectional dependence at the 1% significance level for all series

3.2. Unit Root Test

It is important to investigate the stationarity of the series when using panel estimation methods. It can cause spurious regression when working with non-stationary series. This situation may reduce the reliability of the estimation results. Hence, it is important which stationarity tests to use for the series. For this, cross-section dependency tests are needed. If there is a cross-section dependency in the series, the results of 1st generation stationarity tests such as Levin et al. (2002), Im et al. (2003), MW Maddala & Wu (1999) cannot be trusted. Consequently, 2nd generation stability tests should be used.

When Table 2 is examined, all series show that there is a cross-sectional dependence at the 1% significance level. Hence, in this study, CIPS (Cross-Sectional Augmented IPS) developed by Pesaran (2007) and PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common component) developed by Bai and Ng (2010), which are among the 2nd generation stationarity tests will be used.

The following equation is used for the PANIC test.

$$X = A_{it} + \delta_i' B_t + e_{it},\ e_{it} = \alpha_i e_{it-1} + \varepsilon_{it} \quad (2)$$

In this equation, the residues obtained by the common factors are separated by the principal components approach and the correlation between units is taken into account. In addition, P_a, P_b, and P_{MSB} pooled modified Sargan-Bhargava (Sargan and Bhargava (1983); Stock (1999)) test statistics are also given while performing the PANIC test.

$$P_{a1} = \frac{T\sqrt{N}(\theta^{+}-1)}{\sqrt{2\vartheta^4/\mu^4}} \ , \ P_{a2} = \frac{T\sqrt{N}(\theta^{+}-1)}{\sqrt{(36/5)\vartheta^4\partial^4/\mu^8}}, \tag{3}$$

$$P_{b1} = T\sqrt{N}(\theta^{+}-1)\sqrt{\frac{\frac{1}{NT^2 tr(\hat{\epsilon}'_{-1}\hat{\epsilon})\mu^2}}{\vartheta^4}} \ , \ P_{b2} = T\sqrt{N}(\theta^{+}-1)\sqrt{1/NT^2 tr(\hat{\epsilon}'_{-1}\hat{\epsilon})5\mu^6/6\vartheta^4}\partial^4 \tag{4}$$

$$P_{MSB1} = \frac{\sqrt{N}\left(tr\left(1/NT^2\hat{\varepsilon}'\hat{\varepsilon}\right)-\mu^2/2\right)}{\sqrt{\vartheta^4/3}}, \ P_{MSB2} = \frac{\sqrt{N}\left(tr\left(1/NT^2\hat{\varepsilon}'\hat{\varepsilon}\right)-\mu^2/6\right)}{\sqrt{\vartheta^4/45}} \tag{5}$$

Where, the calculations of P_{a1}, P_{b1}, and P_{MSB1} for the fixed or unfixed model, and P_{a2}, P_{b2}, and P_{MSB2} for the fixed and trend models are taken into account.

The short-term, long-term, and one-sided variance estimates for the ε_{it} residue are $\partial^2, \mu^2, \text{and } \vartheta^2$, respectively (Sahabi, 2019:77). The basic hypothesis for P_a, P_b, and P_{MSB} test statistics states that the series is not stationary.

Another unit root test to be used in the study is the CIPS (Cross Sectionally Augment Im, Pesaran and Shin (2003)) test developed by Pesaran (2007). The CIPS test performs factor decomposition with cross-sectional averages and performs the test by using extended individual section (ADF) regressions using cross-section environments. The basic hypothesis of this test is that there is a unit root in the panel groups. The Extended Dickey-Fuller (CADF) for hypothesis testing is as follows.

$$CADF_{ist} = t_i(a_i) = \ (\Delta y_i' \mathrm{M} w_i y_{i-1})/\sqrt{\hat{\sigma}^2_{\varepsilon i}(y'_{i-1}\mathrm{M} w_i y_{i-1}} \tag{6}$$

The cross-sectionally expanded (CIPS) statistic, which is calculated by taking the individual averages of the CADF statistics, is calculated as

$$CIPS_{ist} = (1/N)\sum_{i=1}^{N} CADF_i \tag{7}$$

Stationarity tests were performed for the series and the results are given in Table 3.

Table 3: Unit Root Test Results

Level	p_a		p_b		p_{msb}		CIPS	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
lnGDP	-0.811	0.784	-0.718	0.954	-0.314	1.123	-2.493***	-2.619
lnREN	0.437	-2.867***	0.398	-2.215**	-0.260	-0.491	-2.511***	-2.445
lnCPTL	0.820	-0.361	1.039	-0.342	1.545	-0.295	-2.105	-2.294
lnLBR	-2.567***	1.909	-2.141**	2.805	-0.772	4.053	-1.699	-1.634
First Dif.	p_a		p_b		p_{msb}		CIPS	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Δ*ln*GDP	-3.206***	-4.932***	-2.186**	-3.418***	-1.439**	-1.913*	-4.237***	-4.714***
Δ*lnREN*	-8.300***	-7.415***	-3.645***	-4.385***	-1.497*	-1.928**	-4.949***	-5.081***
Δ*lnCPTL*	-8.282***	-7.455***	-3.903***	-4.245***	-1.794**	-1.850**	-4.446***	-4.603***
Δ*lnLBR*	-29.622***	-12.987***	-9.263***	-6.858***	-2.757***	-2.623***	-3.595***	-4.190***

Note: ∗∗∗, ∗∗ and ∗ denote significance at the 1%, 5%, and 10% levels, respectively. Δ signifies the first difference. For PANIC and CIPS tests the null hypothesis is nonstationarity.

Table 3 shows that renewable energy use (lnREN) is stationary at the level for the fixed and trend model according to the Pa and Pb tests, and for the fixed model according to the CIPS test. However, for all other tests, the level values are unit rooted. The labor force (lnLBR) is stationary for the fixed model according to the Pa and Pb tests. However, for all other tests, the level values are unit rooted. Consequently, all variables become stationary after taking the first difference. So, all series are I(1).

3.3. Cointegration Tests

The fact that all variables are stationary after taking the first difference, I(1), shows that there may be a cointegration relationship between the series. Hence, it will be investigated whether there is a long-term relationship between the variables. For this, Pedroni (1999) cointegration test was used to test the cointegration relationship between the series, and a cointegration relationship was found. When Table 4 is examined, all test statistics except Group-ρ show that there is a cointegration relationship between renewable energy use and economic growth in the relevant period for energy importing 16 emerging economies.

Table 4: Panel Cointegration Test

Within-dimensian tests	**Constant**	**Constan and trend**
Panel-$\boldsymbol{V}$	-1.668**	8.038***
Panel-$\boldsymbol{\rho}$	-0.351	-1.346*
Panel-$\boldsymbol{PP}$	-2.527***	-5.910***
Panel-$\boldsymbol{ADF}$	-2.465***	-5.212***
Between-dimensian tests		
Group- $\boldsymbol{\rho}$	0.577	0.301
Group -$\boldsymbol{PP}$	-2.603***	-5.576***
Group -$\boldsymbol{ADF}$	-3.610***	-54.996***

Note: ***, ** and * indicate the statistical significance at 1, 5 and 10 percent levels, respectively.

After finding that there is a long-term relationship between green energy use and economic growth, a cointegration coefficient estimation will be obtained. The cointegration coefficient estimations were obtained with the Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Squares Method (DOLS) estimators developed by Pedroni (2000) and Pedroni (2001). FMOLS estimation $\hat{\beta}^*_{GFM} = N^{-1}\sum_{i=1}^{N}\beta^*_{FMi}$ where is β^*_{FMi} obtained from time-series FMOLS estimation of equation (1) for countries. In the DOLS estimator, the model in the form of

$$lnGDP_{it} = \beta_{0i} + \beta_{1i}lnREN_{it} + \beta_{2i}lnCPTL_{it} + \beta_{3i}lnLBR_{it} + \sum_{k=-K_{ii}}^{K_{ii}}\omega_{ik}\Delta lnREN_{it} + \sum_{k=-K_{ii}}^{K_{ii}}\lambda_{ik}\Delta lnCPTL_{it} + \sum_{k=-K_{ii}}^{K_{ii}}\eta_{ik}\Delta lnLBR + \varepsilon^*_{it} \quad (8)$$

$$i = 1, 2, \dots, N; t = 1, 2, \dots, T$$

must be estimated by OLS for each country. Where K_{ii} and $-K_{ii}$ are leads-lags. DOLS estimator can be constructed as $\hat{\beta}^*_{GD} = N^{-1}\sum_{i=1}^{N}\beta^*_{Di}$, where β^*_{Di} is obtained from the estimation of equation (8) (Agir et al., 2011).

Table 5 shows that economic growth has a positive long-run relationship with renewable energy use, real gross fixed capital, and labor force. Furthermore, all coefficients are statistically significant at the 1 percent significance level. Since the variables have natural logarithms, they will be interpreted as elasticity coefficients. When analyzed as coefficients, according to FMOLS estimation results, it is found that labor force use has the most positive effect on economic growth in the relevant period for energy importing emerging economies, while the least positive effect is renewable energy use. When analyzed as a coefficient, a 1% increase in the labor force and green energy use creates an increase of approximately 0.88% and 0.14% in economic growth.

On the other hand, DOLS results showed similar results to FMOLS results in terms of coefficient, sign, and magnitude. According to the DOLS results, it was found that while the use of the labor force had the most positive effect on economic growth in the related period for energy importing emerging economies, the least positive effect was the renewable energy use. When examined as a coefficient, a 1% increase in the labor force and green energy use creates an increase of approximately 0.82% and 0.17% in economic growth. Hence, the findings show that the effect of the increase in the labor force on economic growth in the relevant period is greater than the real gross fixed capital and renewable energy use in energy-importing emerging economies.

Table 5: Panel Cointegration Estimation

	lnREN	lnCPTL	lnLBR
Panel FMOLS	0.141***	0.414***	0.882***
	(0.027)	(0.019)	(0.026)
Panel DOLS	0.171***	0.448***	0.815***
	(0.056)	(0.815)	(0.046)

Note: *** denotes statistical significance at %1 level. Leads-lags were set to 1 for panel DOLS estimator. The statistics are in parentheses.

3.4. Causality Analysis

The cointegration relationship between the series can show that there is a causal relationship between variables. Therefore, if the series has a cointegration relationship, in the long run, it should be estimated with a vector error correction model by extending the VAR model with a single-lagged error correction term. Consequently, VECM model is given as follows:

$$\Delta lnGDP_{it} = \delta_{1i} + \sum_{n=1}^{r} \delta_{11in}\, \Delta lnGDP_{it-n} + \sum_{n=1}^{r} \delta_{12in}\, \Delta lnREN_{it-n} + \sum_{n=1}^{r} \delta_{13in}\, \Delta lnCPTL_{it-n} + \sum_{n=1}^{r} \delta_{14in}\, \Delta lnLBR_{it-n} + \varphi_{1i}\hat{\varepsilon}_{it-1} + v_{1it}$$

$$\Delta lnREN_{it} = \delta_{2i} + \sum_{n=1}^{r} \delta_{21in}\, \Delta lnREN_{it-n} + \sum_{n=1}^{r} \delta_{22in}\, \Delta lnGDP_{it-n} + \sum_{n=1}^{r} \delta_{23in}\, \Delta lnCPTL_{it-n} + \sum_{n=1}^{r} \delta_{24in}\, \Delta lnLBR_{it-n} + \varphi_{2i}\hat{\varepsilon}_{it-1} + v_{2it}$$

$$\Delta lnCPTL_{it} = \delta_{3i} + \sum_{n=1}^{r} \delta_{31in}\, \Delta lnCPTL_{it-n} + \sum_{n=1}^{r} \delta_{32in}\, \Delta lnREN_{it-n} + \sum_{p=1}^{r} \delta_{33in}\, \Delta lnGDP_{it-n} + \sum_{p=1}^{r} \delta_{34in}\, \Delta lnLBR_{it-n} + \varphi_{3i}\hat{\varepsilon}_{it-1} + v_{3it}$$

$$\Delta lnLBR_{it} = \delta_{4i} + \sum_{n=1}^{r} \delta_{41in}\, \Delta lnLBR_{it-n} + \sum_{n=1}^{r} \delta_{42in}\, \Delta lnREN_{it-n} + \sum_{p=1}^{r} \delta_{43in}\, \Delta lnCPTL_{it-n} + \sum_{p=1}^{r} \delta_{44in}\, \Delta lnGDP_{it-n} + \varphi_{4i}\hat{\varepsilon}_{it-1} + v_{4it}$$

Where k represents the optimal delay length, and $\hat{\varepsilon}_{it}$ (1) represents residues obtained from the FMOLS estimates of equation (1). These equations allow the identification of long and short-run causality. When investigating short-run causality, a Wald test is applied with zero constraints on the parameters of the first-differenced variables. When investigating long term causality, the t-statistic of error correction coefficients (φ) is examined with statistically negative and significant significance.

According to the results of Table 6, there is a long-run short- and long-term unidirectional causality running from real gross fixed capital, and labor force to economic growth. It shows a short- and long-term unidirectional causality running from real gross fixed capital, economic growth and labor force to renewable energy use. It also shows a short-term one-way causal statement from economic growth and renewable energy use to real gross fixed capital.

Table 6: Granger Causality

	Short-run causality				Long-run causality
	$\Delta lnGDP$	$\Delta lnREN$	$\Delta lnCPTL$	$\Delta lnLBR$	ECT
$\Delta \boldsymbol{lnGDP}$		2.08 (0.723)	18.74 (0.000)	8.726 (0.069)	-1.567
$\Delta \boldsymbol{lnREN}$	13.26 (0.010)		8.864 (0.065)	7.844 (0.098)	2.178^{***}
$\Delta \boldsymbol{lnCPTL}$	18.20 (0.001)	15.80 (0.003)		6.832 (0.145)	1.261
$\Delta \boldsymbol{lnLBR}$	1.535 (0.820)	1.666 (0.797)	1.310 (0.860)		-0.169

Note: *** indicate the statistical significance at 1% levels. The p-values are in parentheses

4. CONCLUSION AND POLICY IMPLICATIONS

The 16 emerging economies studied in this report are major contributors to global GDP, energy use, fossil fuel consumption, and CO2 emissions. While they have high growth rates, this growth is often accompanied by high energy imports and a reliance on foreign sources of energy, leading to high levels of foreign dependency and a fragile economy. This "dirty growth" also has negative environmental impacts, including high levels of CO2 emissions and environmental degradation. In other words, these economies are achieving high levels of growth, but this growth is unsustainable and unreliable due to their reliance on dirty energy sources.

Renewable energy use means creating employment for economies (Bulavskaya and Reynès, 2018), providing environmental protection, and sustainable development (Akal, 2015; Chen et al., 2019;), reducing the cost of carbon reduction by developing more economical and more efficient technologies (Popp, 2012), having a significant impact on regional development (Miguez et al., 2006), offering great opportunities in the future (Robertson et al., 2020) and giving hopeless hope for energy soon (Chang et al., 2003). It also offers many opportunities such as contributing to economic growth (Alola & Yildirim, 2019). In addition, the fact that fossil fuel, which is still highly dependent on the share of total energy use will run out soon is a serious threat to energy importing economies. Furthermore, the problem of a cleaner, healthier, and the more livable world will occupy the agenda of the world after the Covid-19 global epidemic, which has emerged with negativities such as harmful gases released to global warming.

In this study, the relationship between renewable energy use and economic growth for 16 emerging economies, which are energy importers, which have 25.68% of the world GDP as of 2018 is examined. The study differes from the earlier studies by including a larger dataset, employing new econometric methods, using data from hydro resources in addition to renewable energy use and extending the time period. Besides, the analysis of the effect of clean energy use on economic growth for energy importers and emerging economies is an important contribution to the literature. Hence, investigating the relationship between green energy and economic growth for these economies will be vital for these countries. Consequently, these situations make the results obtained from this study wider, more consistent, and healthier.

PANIC and CIPS unit root tests, Pedroni cointegration, and Granger causality tests were used for the analysis. First of all, stationarity tests were performed for the series and it was shown that the series were stationary after taking the first difference. The Pedroni cointegration test was applied and a cointegration relationship was found, considering that all variables were stationary after taking the first difference and that there could be a cointegration relationship between variables. Finally, the Granger causality test was applied for the variables with a long-term relationship. The results show that increases in economic growth support the conservation hypothesis that the use of renewable energy will increase. Therefore, any negativities to be experienced on economic growth for energy importing emerging economies in the relevant period will cause negative effects on environmental quality, a livable world, and human health together with the use of clean energy in these countries.

The low rate of use of renewable energy (including hydro) in total energy use as of 2018 for 16 energy-importing emerging economies shows that it is well below the desired level. However, while the use of clean energy had a share of 2.64% in total energy use in 1990, the fact that this rate was more than double in 2018 shows that as the economic growth of these economies increases, they are aware of the importance of green energy use and investments and incentives are applied in this field. In addition, the average annual growth rate in the 1990-2018 period is 5.77% in GDP. On the other hand, while an average increase of 3.89% was realized in fossil fuels in the same period, there was an increase of 6.19% in the use of renewable energy. Hence, even though the share of green energy use is not at the desired level, with high economic growth rates in energy-importing emerging economies, the average increase rate increases, and this situation positively reflects on the welfare level, sustainable, reliable, and independent energy and environmental quality (Bilgili & Ozturk, 2015).

All of the suggested factors were found to be consistent with the predicted parameters, models-techniques, and meet theoretical expectations. FMOLS/DOLS models in which all variables were significant could be estimated. Increases in green energy use, real gross fixed capital formation, and labor force positively affect economic growth. As a result, all of the variables put forward have a positive effect on economic growth. The findings obtained in this study by Apergis & Payne (2010), Chen et al. (2020), Ohler & Fetters (2014), Lin and Moubarak (2014), and (Chang et al., 2015) coincide with the findings of the study.

In the light of the results obtained in the study, policymakers have important duties in energy importing emerging economies included in the analysis. For the high growth figures to be sustainable, policies to reduce renewable energy installation costs can be implemented, R&D activities can be increased, equipment to be used in the field of renewable energy can be produced locally, financing or credit facilities can be provided in the field of renewable energy, tax reductions, and tax exemptions and subsidies can be applied. In summary, governments need to create policies and incentives for the use of renewable energy to reduce dependency on foreign sources of energy, improve environmental conditions, and increase awareness and education about green energy. This can be achieved by building new structures with renewable energy, reducing bureaucratic obstacles, and providing accurate information and training on the use of renewable energy.

The efficient use of energy is also very important for energy importing economies. Higher efficiency in energy means that the energy used per output decreases. Besides, increased efficiency also reflects positively on environmental quality, resulting in a reduction in CO2 emissions. However, it is important to sustain the increasing environmental quality. In other words, it is the desired situation to increase environmental quality and ensure that this situation is sustainable. Since renewable energy is important for the increase of energy efficiency, increasing the use of renewable energy for emerging economies is not an option but a necessity (Akdag & Yildirim, 2020; Alola et al., 2022).

Considering the limitations of the study, renewable energy use (hydro and wind, solar, etc.) for energy importing countries was investigated with the relationship between total green energy use and economic growth. Hence, the use of separate renewable energy sources will give more detailed results. However, besides renewable energy, investigating the relationship between non-renewable energy use and economic growth can provide more information.

In the literature, There are no studies investigating the relationship between renewable energy and economic growth for energy-importing or exporting countries. Therefore, in the studies following this study, the relationship between renewable energy use and economic growth can be examined separately for these country groups. In addition, researching the subject at the sectoral level for these economies will significantly contribute to the literature.

NOTES

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[1] In the IMF's world economic report published in 2015, Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, 23 countries such as Turkey, Ukraine and Venezuela are classified as Emerging Economy (IMF: WEO, 2015). Among these countries, Argentina, Bangladesh, Bulgaria, Chile, China, Hungary, India, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Thailand, Turkey, and Ukraine are energy importing countries.

AUTHOR STATEMENT

Statement of Research and Publication Ethics

This study has been prepared in accordance with scientific research and publication ethics.

Author Contribution

The author performed the whole study alone.

Conflict of Interest

There is no conflict of interest arising from the study for the authors or third parties.

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