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Energy imports as inhibitor of economic growth: The role of impact of renewable and non-renewable energy consumption

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ABSTRACT
This study investigates the role of energy imports in domestic production function in the case of 15 energy-importing countries for the period of 1995–2015. Apart from energy imports, renewable energy consumption, non-renewable energy consumption, capital, trade openness, and urbanization are included in the growth model. In doing so, long-run elasticity coefficients are estimated with the Dynamic Seemingly Unrelated Regressions (DSUR) model after determining the cointegration relationship between the variables. In addition, for robustness checks, Panel Correlated Standard Errors (PCSE) and Feasible Generalized Least Squares (FGLS) estimators are applied. Our results show that renewable energy consumption, non-renewable energy consumption, trade openness, and capital have a positive effect on economic growth. Energy imports negatively affect economic growth. The Dumitrescu-Hurlin causality analysis reveals a bidirectional causality relationship between renewable energy consumption, capital, trade openness, urbanization, and economic growth. A unidirectional causality relationship exists from economic growth to non-renewable energy consumption and energy imports. This analysis can be interpreted as having a negative impact on economic growth by putting pressure on the current account deficit due to energy imports. Therefore, investments in the renewable energy sector will play an important role in economic growth.

KEYWORDS Energy imports; economic growth; DSUR; Dumitrescu-Hurlin causality

JEL CLASSIFICATIONS F43, O11, Q43

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1. Introduction

Energy is considered one of the major driving forces of economic growth in all economies (Augutis et al. 2011). The continuation of production activities depends on

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energy use (Bulut and Menegaki 2020). Energy demand, an indicator of sustainable growth and development, is a global problem that covers countries all over the world (Mohammed, Mustafa, and Bashir 2013). Therefore, the demand for energy globally is constantly increasing. International Energy Agency (IEA 2021) shows that the total energy supply in the world increased by 2.6 times between 1971 and 2019, from 230 EJ to 606 EJ. However, the fact that the ratio of coal, oil, and natural gas, which is called fossil fuels among the types of energy produced and consumed, is still high, brings many problems for countries and societies. Countries strive to access energy sources while trying to minimize the destruction caused by this energy used. In this context, continued dependence on fossil fuels causes climate change due to greenhouse gas emissions and accelerates environmental degradation (Gottschamer and Zhang 2016). These emissions, which mean a serious threat to the environment and man, significantly destabilize living life with adverse natural phenomena such as climate change and global warming. Realizing this serious threat, countries began to use renewable energy as a tool, turning to energy diversity (Pata 2018). This search for energy has a critical role for all countries; energy security has made renewable energy almost a necessity beyond necessity due to factors such as limited fossil energy resource reserves, price volatility, and climate change. Thus, renewable energy sources have come to the fore for sustainable development (Ozturk and Bilgili 2014). The dependence of countries on energy imports can have negative effects on economic growth. Therefore, dependence on energy imports can be balanced by developing renewable energy sources (Marques and Fuinhas 2012).

Energy imports can positively affect economic growth or negatively. As the amount of energy needed increases, energy imports increase, and economic growth occurs due to more energy consumption (Demirer, Ferrer, and Shahzad 2020). However, although increases in energy imports promote economic growth by supporting production growth, they destabilize the current account and can have negative effects on economic growth with the increase of the current account deficit (Bildirici and Kayikci 2022). The negative consequences of dependence on energy imports on the current account balance increase the potential vulnerability of that country. If a country has both an energy-related trade deficit and a current account deficit, the vulnerability will be greater. In other words, in countries where a large part of the current account deficit is due to the energy-based trade deficit, the vulnerability will increase even more. These negativities are the responsibility of the relevant country; may lead to deterioration in macroeconomic indicators such as competitiveness, economic growth, and employment (Canton et al. 2013). Therefore, increasing the use of domestic and renewable energy sources will contribute to long-run economic growth by reducing the dependence on energy and the amount of foreign currency that countries allocate for energy imports. In addition, the diversification of the sources from which energy is imported will reduce the exporter's energy supply risk and ensure energy security. Thus, sustainable economic growth will be achieved (Bildirici and Kayikci 2022).

The economic growth of countries that meet energy demand via imports is adversely affected by instability in energy prices (Arshad, Zakaria, and Junyang 2016). Rising energy prices are pushing up domestic prices, causing more foreign exchange outflows from energy-importing countries to energy-exporting countries (Gottschamer and Zhang 2016). Production costs increase and productivity decreases as an increase in energy prices increases the cost of energy imports. Rising costs and falling productivity reduce the level of real wages but also increase unemployment and inflation. As a result, macro variables and economic growth are affected by the change in energy prices (Marques and Fuinhas 2012).

This study can contribute to existing literature in five respects: (i) Although, there are numerous studies in the literature examining the relationship between energy consumption and economic growth. The number of studies investigating the effect of renewable and non-renewable energy consumption on economic growth is quite limited with the mediating role of energy imports. Therefore, this study is important to fill this gap in the existing literature. Therefore, this study is to investigate the impact of energy imports, renewable energy consumption, and non-renewable energy consumption on economic growth in 15 leading countries in energy imports for the period of 1995–2015. The production function also includes capital, urbanization, and trade openness as additional determinants of economic growth. (ii), For empirical purposes, we apply second-generation panel data approaches. These tests are CADF and CIPS tests for unit root testing and the cointegration relationship between variables is investigated by applying Kao (1999), Pedroni (2004), Westerlund (2005), and Westerlund (2007) tests. (iii), The long-run elasticity coefficients are estimated by the DSUR method. The PCSE and FGLS forecasters are also consulted to support the results of the predicted model. (iv), The causality relationship between the variables is investigated by applying the Dumitrescu-Hurlin causality approach. The empirical findings that energy imports negatively affect economic growth and renewable energy consumption positively affects economic growth may guide the policies to be implemented for the development of renewable energy sources. (v), Finally, the findings of the study will be able to identify the determinants of economic growth in terms of energy-dependent countries and help these countries to organize their sustainable development goals and strategies more realistically and accurately.

2. Literature review

There are a lot of studies in the existing literature on the relationship between economic growth and energy (renewable and non-renewable) consumption. However, nearly all of these studies did not focus on the role of energy imports as the mediator in the relationship between economic growth and energy consumption. The literature on the subject was examined, only the studies carried out by Marques and Fuinhas (2012) and Bildirici and Kayikci (2022) in which energy imports were included as an additional factor of economic growth. For example, Marques and Fuinhas (2012) used data for the period of 1990–2007 to examine the relationship between renewable energy consumption, dependence on energy imports, and economic growth for 24 European countries. They concluded that the dependence on energy imports negatively affects economic growth. In addition, they found no evidence that renewable energy consumption boosts economic growth. They further explain the fact that investments in renewable energy sources require high costs and thus lead to a slowdown in economic activity. Bildirici and Kayikci (2022) analyzed the relationship between economic growth, current account balance, energy imports, and militarization using the Markov Switching-Bayesian Vector Auto Regressive approach for China, Israel, and South Korea, which have a high rate of arms exports and imports. Their empirical findings show that militarization, energy imports, economic growth, and current balance are interrelated. They also concluded that energy imports have increased due to militarization and economic growth, and negative energy shocks and militarization have negatively affected the current account balance.

In recent years, many studies have been carried out on the relationship between energy consumption and economic growth. For example, Payne (2010) and Ozturk (2010), studied the relationship between energy consumption and economic growth and proposed four testable hypotheses. Many scientists have done important research to confirm such hypotheses. Some scientists have recently submitted extensive literature research on this subject (Aydin 2019; Fan and Hao 2020; Inglesi-Lotz 2016; Menegaki 2011; Shahbaz et al. 2017; Tugcu and Topcu 2018). The first hypothesis on the relationship between energy consumption and economic growth is called the *energy-led growth hypothesis*. This hypothesis argues that an increase in energy consumption increases economic growth and therefore energy is an important input for output in production function (Destek and Aslan 2017; Hamit-Haggar 2016; Mbarek, Saidi, and Rahman 2018; Ozturk and Bilgili 2014; Zallé 2019). The *conservative hypothesis* reveals the presence of a unidirectional causality relationship from economic growth to energy consumption. Therefore, policies aimed at increasing or reducing energy consumption do not affect economic growth (Destek 2016; Menegaki 2011; Rasoulinezhad and Saboori 2018). The feedback hypothesis argues that energy consumption and economic growth are interdependent and that there is a bidirectional causality relationship between the variables (Ben-Salha, Dachraoui, and Sebri 2021; Jebli and Youssef 2015; Pao and Fu 2013; Salim, Hassan, and Shafiei 2014; Shahbaz et al. 2016; Shahbaz et al. 2018). The neutrality hypothesis assumes that there is no causality between energy use and economic growth and that any policy towards one variable will not affect the other (Alper and Oguz 2016; Fan and Hao 2020; Payne 2010; Samuel, Klobodu, and Apio 2018; Tuna and Tuna 2019).

Although the causality between energy consumption and economic growth has been studied extensively in existing literature there is no consensus on this issue. In many studies, a undirectional causality relationship from economic growth to renewable energy consumption is found (Chen, Wang, and Zhang 2019; Destek and Aslan 2017; Kahia, Aïssaa, and Lanouar 2017; Menyah and Wolde-Rufael 2010; Saad and Taleb 2018). However, in some studies, a unidirectional causality relationship has been reached from renewable energy consumption to economic growth (Al-Mulali et al. 2013; Cai, Sam, and Chang 2018; Mbarek, Saidi, and Rahman 2018; Yazdi and Shakouri 2017). Furthermore, some research has found a bidirectional causality relationship between the variables (Apergis and Payne 2010; Bloch, Rafiq, and Salim 2015; Chen, Wang, and Zhang 2019; Rafindadi and Ozturk 2017; Razmi et al. 2020; Tuna and Tuna 2019). In some studies, there was no causality relationship between the variables (Alam and Murad 2020; Lin and Moubarak 2014; Menegaki 2011). In terms of short-run and long-run, there are different results in studies on the relationship between economic growth and renewable energy consumption. For example, some studies have found a bidirectional causality between renewable energy consumption and economic growth (Al-Mulali et al. 2013; Apergis and Payne 2011; Chen, Wang, and Zhang 2019; Shahbaz et al. 2015). In contrast, in terms of Iranian sampling, Yazdi and Shakouri (2017) found a feedback effect between the variables in the short run; Lin and Moubarak (2014) found a bidirectional causality relationship between renewable energy consumption and economic growth in the long run. No causality between renewable energy consumption and economic growth is also noted in terms of the short-run by Lin and Moubarak (2014), Dogan (2015), and Bhattacharya et al. (2016) however, there is a unidirectional causality from economic growth to renewable energy consumption (Attiaoui et al. 2017; Kahia, Aïssaa, and Lanouar 2017; Mbarek, Saidi, and Rahman 2018).

There is different evidence of the relationship between non-renewable energy consumption and economic growth. Various studies have suggested that fossil-derived energy consumption has a negative effect on economic growth (Awodumi and Adewuyi 2020; Mohammadi and Parvaresh 2014; Shahbaz et al. 2017). However, different results were reached in other studies. For example, Salamaliki and Venetis (2013), Yildirim, Sukruoglu, and Aslan (2014), Rafindadi and Ozturk (2017), Mensah et al. (2019), Wang, Jiang, and Zhan (2019), Magazzino et al. (2021) have demonstrated that non-renewable energy consumption does not affect economic growth. Some studies have produced mixed results depending on the sample country and the impact of non-renewable energy consumption on economic growth has been differentiated by country (Mezghani and Haddad 2017; Rodríguez-Caballero and Ventosa-Santaulària 2017). As a result, there is no consensus on the relationship between economic growth and energy consumption; it is due to the different sample and analysis periods. In addition, the use of different econometric methods also causes different findings to differ. Table 1 presents a summary of studies examining the impact of renewable energy consumption and non-renewable energy consumption on economic growth in the existing literature.

3. The empirical model and data

The panel data of 15 countries that are at the forefront of energy imports is analyzed for 1995–2015.[1] This study focuses to investigate the effect of renewable energy consumption, non-renewable energy consumption, and energy imports on economic growth. Capital, trade openness, and urbanization are also included in production functions as additional factors of economic growth. Thus, in addition to theoretical literature, the regression model is used as follows to estimate this relationship following the empirical studies by Bildirici and Kayikci (2022), Zafar et al. (2019), and Kahia, Aïssaa, and Lanouar (2017):

$$GDP_{i,t} = \beta_0 + \beta_1 RE_{i,t} + \beta_2 NRE_{i,t} + \beta_3 EI_{i,t} + \beta_4 GFC_{i,t} + \beta_5 TO + \beta_6 UP + \varepsilon_{i,t} \quad (1)$$

In equation (1), $i = 1, \ldots, N$ shows cross-section units, $t = 1, \ldots, T$ time period, ε_{it} error terms.

$\beta_1, \ldots\ldots \beta_4$ shows parameters that measure the effect of arguments on the dependent variable. The variables, definitions of variables, resources, and studies using such variables are presented in Table 2.

4. Methodological framework

Primarily, cross-section dependence and homogeneity of the slope parameter approaches are investigated. Two alternative situations arise regarding the assumptions of panel unit root tests. First-generation panel unit root tests are based on the assumption that cross-section dependence does not exist. Second-generation panel unit root tests assume that cross-section dependence exists. For example, Robertson and Symons (2000), Anselin and Baltagi (2001), and Pesaran (2004) demonstrated that cross-section dependence should be taken into account in panel data analysis. In addition, Phillips and Sul (2003) argue that the disregard for cross-section dependence gives inactive estimates. The investigation of cross-section dependence is important to avoid deviations

Table 1. Summary literature review.

Author/Authors	Country/Countries	Period	Method	Long-Run Impact	Causality
Apergis and Payne (2010)	15 countries	1980–2005	FMOLS	NRE-EG (+)	RE↔EGNRE↔EG
Apergis et al. (2010)	19 developed and developing countries	1984–2007	PECM	NRE-EG (+)RE-EG (+)	RE↔EGNRE↔EG
Menyah and Wolde-Rufael (2010)	USA	1960–2007	VAR, Granger Causality	NRE-EG (+)RE-EG (+)	EG →NREEG →RE
Apergis and Payne (2011)	Six Central American countries	1980–2006	FMOLS	RE-EG (+)	RE↔EG
Menegaki (2011)	27 European countries	1997–2007	REM	RE-EG (no)	RE ≠ EG
Marques and Fuinhas (2012)	24 European countries	1990–2007	PCSE	RE-EG (no)	–
Apergis and Payne (2012)	80 countries	1990–2007	FMOLS	NRE-EG (+)RE-EG (+)	RE↔EGNRE↔EG
Tugcu, Ozturk, and Aslan (2012)	G7 countries	1980–2009	ARDL	NRE-EG (+)RE-EG (+)	RE↔EGNRE↔EG
Pao and Fu (2013)	Brazil	1980–2010	VECM	RE-EG (+)	RE↔EG
Sebri and Ben-Salha (2014)	BRICS countries	1971–2010	VECM	RE-EG (+)	RE↔EG
Bloch, Rafiq, and Salim (2015)	China	1977–2013 1965–2011	ARDL,VECM	RE-EG (+)	RE↔EG
Ibrahiem (2015)	Egypt	1980–2011	ARDL	RE-EG (+)	RE↔EG
Shahbaz et al. (2015)	Pakistan	1972–2011	ARDL,VECM	RE-EG (+)	RE↔EG
Kahia, Aïssaa, and Lanouar (2017).	MENA net oil exporting countries	1980–2012	FMOLS, VECM	RE-EG (no)	EG →RE
Attiaoui et al. (2017)	22 African countries	1990–2010	ARDL-PMG approach and ECM Granger causality.	RE-EG (+)	EG →RE
Rafindadi and Ozturk (2017)	Germany	1971–2013	Combined cointegration test, VECM	RE-EG (+)	RE↔EG
Saad and Taleb (2018)	12 EU countries	1990–2014	VECM	RE-EG (+)	EG →RE
Mbarek, Saidi, and Rahman (2018).	Tunisia	1990–2015	VECM	RE-EG (No)	RE →EG
Cai, Sam, and Chang (2018)	G7 countries	1965–2015	ARDL	RE-EG (+)	RE →EG

(*continued*).

Table 1. Continued

Author/Authors	Country/Countries	Period	Method	Long-Run Impact	Causality
Samuel et al., (2018)	30 Sub-Saharan African (SSA)	1980–2012	FMOLS and DOLS	NRE-EG (+)RE-EG (+)	RE ≠ EGNRE ≠ EG
Rasoulinezhad and Saboori (2018)	Commonwealth of Independent States 12 countries	1991–2012	DOLS and FMOLS	RE-EG (+)NRE-EG (no)	RE↔EGNRE↔EG
Gozgor, Lau, and Lu (2018)	29 OECD countries	1990–2013	PQR, ARDL	NRE-EG (+)RE-EG (+)	RE → EGNRE → EG
Gozgor (2018)	USA	1965–2016	ARDL	RE-EG (+)	RE → EG
Zafar et al., (2019)	16 in Asia-Pacific Economic Cooperation	1995–2015	FMOLS	NRE-EG (+)RE-EG (+)	RE → EGNRE → EG
Tuna and Tuna (2019)	ASEAN-5 countries	1980–2015	Hacker and Hatemi-J (2006) and Hatemi-J (2012) causality	NRE-EG (+)RE-EG (+)	RE↔EGNRE↔EG
Chen, Wang, and Zhang (2019)	China	1980–2014	ARDL	RE-EG (+)	EG → RE
Razmi et al. (2020)	Iran	1990–2014	ARDL	RE-EG (+)	RE↔EG
Alam and Murad (2020)	25 OECD countries	1970–2012	ARDL FMOLS and DOLS	RE-EG (+)	RE ≠ EG
Ghosh and Kanjilal (2020)	India	1971–2014	Regime shift co-integration and VECM	RE-EG (+)	EG → RE
Wang and Wang (2020)	OECD countries	2005–2016	Panel threshold model REC	RE-EG (+)	EG → RE
Rahman and Velayutham (2020)	Five South Asian countries	1990–2014	FMOLS and DOLS	NRE-EG (+)RE-EG (+)	EG → REEG ≠ NRE
Ivanovski, Hailemariam, and Smyth (2021)	39 countries- RECAI ranking	1990–2015	Dynamic-CCEMG	NRE-EG (+)RE-EG (+)	–

Note: EG: Economic growth, RE: Renewable energy consumption, NRE: Non-renewable energy consumption, PECM: Panel error correction model, REM: Random effect model, VECM: Vector correction error models, PQR: Panel quantile regression, ARDL: Auto regressive distributed lag, VAR: Variance decomposition analysis. The (+) sign indicates the positive relationship between the related variables, and the (-) sign indicates the negative relationship. → sign indicates the undirectional causality relationship between variables, ↔ the sign indicates the bidirectional causality relationship and the ≠ sign indicates that there is no causality relationship.

Table 2. Variables, descriptions, and data source.

Variables	Descriptions	Source	Studies using the variables
GDP	GDP growth (annual %)	World BankWDI-2021	Al-Mulali et al. (2013); Chang (2015)
RE	Renewable energy consumption (% of total final energy consumption)	World BankWDI-2021	Wang and Wang (2020); Razmi et al. (2020); Ivanovski, Hailemariam, and Smyth (2021)
NRE	Fossil fuel energy consumption (% of total)	World BankWDI-2021	Kahia, Aïssaa, and Lanouar (2017); Rahman and Velayutham (2020)
EI	Energy imports, net (% of energy use)	World BankWDI-2021	Bildirici and Kayikci (2022)
GFC	Gross fixed capital formation (% of GDP)	World BankWDI-2021	Zafar et al. (2019); Dash (2021)
TO	Trade (% of GDP)	World BankWDI-2021	Sohag et al. (2015); Wang and Zhang (2021)
UP	Urban population (% of total population)	World BankWDI-2021	Frick and Rodríguez-Pose (2018); Liang and Yang (2019)

and incorrect predictions in panel data studies. Cross-section independence is based on the assumption that other countries that make up the panel are not affected by a macroeconomic shock that occurs in any of the countries. So, empirical results obtained in the analyses without considering cross-section dependence will be deviated and inconsistent. Therefore, it is necessary to be tested whether there is dependence between cross-sections before starting the analysis (Menyah, Nazlioglu, and Wolde-Rufael 2014).

While testing cross-section dependence, cross-section dependence tests developed by Friedman (1937) and Frees (1995) are preferred as the unit size of panel data is greater than the time dimension. Breusch and Pagan LM test by Breusch and Pagan (1980) and, Pesaran scaled LM test by Pesaran (2004) is preferred when the time dimension is greater than the unit size. In some panel data studies (Ullah et al. 2021; Yang et al. 2021; Zafar et al. 2019) cross-section dependence Pesaran CD test developed by Pesaran (2004) is being investigated. In some panel data studies (Danish et al. 2019; Majeed et al. 2021) Pesaran scaled LM test and Breush-Pagan LM test is preferred as well as the Pesaran CD test. We prefer the cross-section dependence test in terms of these three tests. Breusch and Pagan's (1980) LM test, the first test used in the study, was fixed N, while $T \to \infty$ was a test based on correlation coefficients of residues. LM test statistics are calculated as in equation (2):

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{2}$$

In equation (2), $\hat{\rho}$ shows the sample estimate of the binary correlation of the remains. In this test, the null hypothesis states that there is no relationship between cross-sections and has a degree of asymptotic distribution of $\frac{N(N-1)}{2}$. It is assumed that this test will be used when the time dimension is greater than the cross-section size. The second test used in the study was CD_{LM} developed by Pesaran (2004) test. This test is an improved version of Breusch and Pagan's (1980) LM test. It is expressed as in equation (3):

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \tag{3}$$

The third test used in the study is the CD test developed by Pesaran (2004). This test is shown in equation (4):

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=1+1}^{N}\hat{\rho}_{ij}\right) \tag{4}$$

CD testing is based on the sum of correlation coefficients between cross-section residues. In the case of the null hypothesis, which states that there is no relationship between cross-sections, test statistics show a standard normal distribution. Created for tests shown in equations (2–4), H_0 the hypothesis is that there's no cross-section dependence, H_1 the hypothesis states that there is a cross-section dependence. According to the test results, if H_0 the hypothesis is accepted, the analysis is continued with the first generation panel unit root tests, while if H_1 the hypothesis is accepted, the analysis should be continued with the second-generation panel unit root tests (Baltagi 2008).

Homogeneity is important in determining the appropriate unit root and cointegration tests in panel data analysis. After the investigation of cross-sectional dependence, it is tested for homogeneity of the slope. The coefficients of the heterogeneous slope are determined first by Δ tests developed by Swamy (1970) and later calculated by Pesaran and Yamagata (2008). However, if there is heteroskedasticity and serial correlation in regression errors, Δ tests developed by Blomquist and Westerlund (2013) are used. The HAC version of the homogeneity test based on the preferred Blomquist and Westerlund (2013) delta test is shown in equation (5):

$$\Delta_{HAC} = \sqrt{N}\left(\frac{N^{-1}S_{HAC} - k}{\sqrt{2k}}\right) \tag{5}$$

The S_{HAC} given in equation (5) is shown in equation (6):

$$S_{HAC} = \sum_{i=1}^{N} T(\hat{\beta}_i - \hat{\beta})'(\hat{O}_{\dot{I}T} V_{\dot{I}T}^{-1} \hat{O}_{\dot{I}T})(\hat{\beta}_i - \hat{\beta}) \tag{6}$$

$\hat{\beta}$ value as shown in equation (7):

$$\hat{\beta} = \left(\sum_{i=1}^{N} T\hat{O}_{\dot{I}T} V_{\dot{I}T}^{-1}\hat{O}_{\dot{I}T}\right)^{-1} \sum_{i=1}^{N}\hat{O}_{\dot{I}T}\hat{V}_{\dot{I}T}^{-1}X_i' M_T y_i \tag{7}$$

$\hat{\beta}_i$, i shows the OLS estimator for cross-section units. Heteroskedasticity and serial correlation are explained using the HAC forecaster in equation (8):

$$\hat{V}_{\dot{I}T} = \hat{\Gamma}_i(0) + \sum_{j=1}^{T-1} K\left(\frac{j}{M_{\dot{I}T}}\right)[\hat{\Gamma}_i(j) + \hat{\Gamma}_i(j)'] \tag{8}$$

If the null hypothesis is rejected in the homogeneity test and the alternative hypothesis is accepted, slope coefficients are heterogeneous. In this case, it is appropriate to prefer second-generation tests.

Since cross-sectional dependence of series is detected, second-generation panel unit root tests should be used. These tests are generally based on three different approaches.

These are bootstrap suggested by Maddala and Wu (1999), factor analysis introduced by Bai and Ng (2004), and surrogate variables approaches suggested by Pesaran (2007), respectively. Cross-Sectionally Augmented ADF (CADF) and Cross-Sectionally Augmented IPS (CIPS) panel unit root tests developed by Pesaran (2007) were preferred. Pesaran (2007) proposes the method of surrogate variables to destroy cross-sectional dependence. This method uses an extended version of the ADF unit root test with delayed cross-section averages. In addition, the first difference of this regression destroys inter-unit correlation. The approach is known as CADF. Pesaran (2007) uses equation (9) for the CADF unit root test:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + u_{it} \tag{9}$$

To take cross-sectional dependence into account, the error term is defined as in equation (10):

$$u_{it} = \gamma f_t + \varepsilon_{it} \tag{10}$$

The f_t equation (10) shows the unobservable factors. The f_t is assumed to be stationary. In this test, cross-sectional dependence in the model is due to unobserved factors, and $\Delta\bar{y}_{it}$ and $\bar{y}_{i,t-1}$, which express the cross-sectional averages, are added to the model instead of unobservable common factors. In the absence of autocorrelation in the error term or factor, CADF regression is as in equation (11):

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + d_0 \bar{y}_{t-1} + d_1 \Delta\bar{y}_t + \varepsilon_{it} \tag{11}$$

In equation (7), $\bar{y}$ is the average of all observations over time. In case of autocorrelation in the error term or factor, by adding the first-degree differences of y_{it} and $\bar{y}_{it}$, the equation can be expanded as in equation (12).

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{i,j} \Delta\bar{y}_{t-j} + \sum_{j=0}^{p} \beta_{i,j} \Delta y_{i,t-j} + \mu_{i,t} \tag{12}$$

After CADF regression is estimated, the averages of the t-statistic of delayed variables are taken to calculate the CIPS statistics in equation (13):

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \tag{13}$$

To determine the existence of a cointegration relationship between the variables, the appropriate panel cointegration test must be determined. Since all series covered in the study had cross-section dependence, cointegration tests developed by Kao (1999), Pedroni (2004), and Westerlund (2005) are used, which took into account cross-sectional dependence. In the study, the long-run relationship between variables is also investigated by the cointegration test developed by Westerlund (2007). Westerlund's (2007) test is a cointegration test based on a big correction model so that the cointegration relationship between two or more variables can be tested. Banerjee, Dolado, and Mestre (1998) developed this test time series is an extended version of the cointegration test for panel data. Westerlund (2007) consists of four basic test statistics based on structural dynamics. G_t and G_a are called group statistics, while P_t and P_a are called panel statistics. When estimating group statistics, bug correction constants are evaluated individually for each cross-section. Rejection of the null hypothesis indicates that there is a cointegration relationship between the variables for at least one of the cross-sections. The rejection of the null hypothesis in the panel statistics indicates that there is a cointegration relationship between the variables for the entire panel. The equality of cointegration developed by Westerlund (2007) is expressed as in equation (14) (Zafar et al. 2019):

$$\Delta Y_{it} = \delta_i d_t + \alpha_i Y_{i,t-1} + \gamma_i X_{i,t-1} + \sum_{j=1}^{pi} \alpha_{ij} \Delta Y_{i,t-1} + \sum_{j=-qi}^{pi} \gamma_{ij} \Delta X_{i,t-1} + \varepsilon_{it} \tag{14}$$

In equation (14), i cross sections, t observations, d_t deterministic components, α_i indicates the rate of convergence to the state of equilibrium after an unexpected shock.

In dynamic panel data models, it is important to take into account the internality problem as well as heterogeneity and inter-unit correlation for forecasters to be effective and deviate-free. After a long-run cointegration relationship was detected between the variables, long-run flexibility coefficients are estimated with the main estimator, DSUR regression estimator was selected as the most appropriate estimator due to its solving of the internality problem, taking into account heterogeneity and inter-unit correlation, and because the cross-section size was smaller than the time size in the sample used in the analysis. It can also be said that this estimator is an effective estimator based on the findings from Monte Carlo simulation in the case of T > N, in which high cross-sectional dependence between error terms and cross-sections show heterogeneous properties (Mark, Ogaki, and Sul 2005).

After determining the long-term cointegration relationship between the variables in the study, the long-term elasticity coefficients are estimated with the main estimator, DSUR developed by Mark, Ogaki, and Sul (2005). Mark, Ogaki, and Sul (2005) suggest that the DSUR technique gives effective results in cases where there is cross-sectional dependence and slope heterogeneity between series. In addition, this estimation technique is preferred in the T > N case and in small samples. For these reasons, equation (15) is initially used for the DSUR method preferred in the study:

$$\underline{y}_t = (\underline{\beta}', \underline{\delta}_p') W_t + \underline{u}_t \tag{15}$$

The long-term covariance matrix of $\underline{u}_t$ is denoted by Ω_{uu}. The DSUR estimator, known as Ω_{uu}, is shown in equation (16):

$$\begin{bmatrix} \hat{\underline{\beta}}_{dsur} \\ \underline{\delta}_{p,dsur} \end{bmatrix} = \left(\sum_{t=p+1}^{T-p} W_t \Omega_{uu}^{-1} y_t \right)^{-1} \tag{16}$$

After the long-term parameters were estimated by the DSUR method in the study, the consistency test of the model was performed with two alternative estimation methods such as PCSE and FGLS, which take into account the cross-sectional dependence. The PCSE method was first proposed by Beck and Katz (1995). Beck and Katz (1995) stated that PCSE predictions that produce standard errors based on large T asymptotics also yield good results in small panels. In addition, the PCSE estimator, which produces standard errors that are resistant to changing variance, also controls autocorrelation and cross-sectional dependence (Hoechle 2007).

The panel causality test developed by Dumitrescu and Hurlin (2012), in the last stage of the study, is applied. This test provides effective results in heterogeneous panels where cross-sectional dependence is detected. In addition, it can make predictions in any situation where there is a cointegration relationship and there is no cointegration relationship. Basic regression is shown in equation (17):

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{k=1}^{K} \gamma_{i,k} X_{i,t-k} + \varepsilon_{it} \tag{17}$$

Equation (17), $X_{i,t}$ and, $y_{i,t}$ for each i, it shows the stationary variable observations in the t period. It is assumed that the coefficients differ between each i but do not change over time. It is assumed that the latency length is the same for each i and that the panel is balanced. The null hypothesis states that there is no causality, and the alternative hypothesis is causality.

5. Empirical findings and discussion

The summary statistics of panel data from 15 leading countries in energy imports with an observation value of 315 for 1995–2015 is reported in Table 3. Trade openness contains an average value of 92.798. The variable with the lowest average is economic growth with a value of 2.838. Non-renewable energy consumption has the highest median with a value of 82.718. The variable with the lowest median is economic growth with a value of 2.735. When maximum values are taken into account, the variable with the highest value is trade openness (351.132), while the lowest variable is economic growth (25.176). While the minimum value is the lowest of economic growth (−10.149), the highest variable is non-renewable energy consumption (63.946). The standard deviation is the highest for trade openness (64.136), while the lowest variable is economic growth (3.568). In addition, the variable with the highest skewness value is trade openness 1.796, while the variable with the lowest skewness value is urbanization with a value of −0.009. Correlation results for variables are shown in Table 3. As shown in Table 3, there is a positive correlation between non-renewable energy consumption, energy imports, capital and trade openness, and economic growth. Renewable energy consumption and urbanization and economic growth are negatively correlated.

In the vast majority of panel data studies, cross-sectional dependence and slope homogeneity tests are applied as preliminary tests for determining long-run estimator and causality approach (Dogan and Aslan 2017; Majeed et al. 2021; Shahbaz et al. 2020; Zafar et al. 2019). In the second step, cross-sectional dependence is analyzed for each of the variables. Cross-sectional dependence results are shown in Table 4. As shown in Table 4, the findings from LM and CD tests indicate that the null hypothesis i.e. there is no dependence between cross-sections for all series, is rejected, and therefore cross-sectional dependence exists. This shows that shocks in one of the 15 countries included in the analysis tend to spread to other countries. On the other hand, the results of delta tests used to investigate the presence of slope homogeneity are shown in Table 5. The results indicate that the null hypothesis, which refers to the existence of slope homogeneity, will be rejected, so the model has slope heterogeneity. This result can be interpreted as having heterogeneous panel data. The stationarity of the series for 15 countries that imported the most energy was investigated by Pesaran (2007) CADF and CIPS tests from second-generation panel unit root tests developed under

Table 3. Summary statistics.

	GDP	RE	NRE	EI	GFC	TO	UP
Mean	2.838	11.117	82.828	75.754	23.203	92.798	74.894
Median	2.735	7.681	82.718	75.768	22.696	67.457	76.181
Max.	25.176	35.790	97.382	98.829	37.497	351.132	97.876
Min.	−10.149	0.443	63.946	54.735	10.770	16.390	51.109
Std. dev.	3.568	9.469	7.880	11.268	4.246	64.136	12.971
Skewness	0.488	1.016	−0.043	0.319	0.413	1.796	−0.009
Kurtosis	7.989	2.835	2.289	2.202	3.921	6.098	1.875
Obs.	315	315	315	315	315	315	315
GDP	1.000						
RE	−0.082	1.000					
NRE	0.087	−0.471	1.000				
EI	0.062	−0.423	0.462	1.000			
GFC	0.360	−0.195	−0.062	0.069	1.000		
TO	0.149	−0.235	−0.106	0.401	−0.214	1.000	
UP	−0.051	−0.299	0.153	0.277	−0.101	0.067	1.000

cross-section dependence. Panel unit root tests are calculated for constant and constant-trend models. Test results are given in Table 6. The findings for the constant-trend model indicate that all the variables included in the analysis are stationary at first difference.

It is decided to use Kao, Pedroni, and Westerlund panel cointegration methods that take into account cross-section dependence after unit root testing. In addition, the Westerlund ECM cointegration test, which takes into account cross-section dependence, and the cointegration relationship between the variables are investigated. The empirical findings from cointegration tests are shown in Tables 7 and 8. According to Pedroni and Kao test results in Table 7, the null hypothesis stating that there is cointegration between the variables is rejected at a 1% significance level and the Westerlund test result at a level of 5% significance. Therefore, it is found that there is a long-run relationship between the variables. Since two of Westerlund's ECM tests (G_t and P_t) in Table 8 are statistically significant at the 1% significant level, the null hypothesis stating that there is no cointegration between variables is rejected. The cointegration test results indicate the existence of a long-run relationship between independent and dependent variables.

After the long-run relationship between the variables is detected, long-run flexibility coefficients are estimated with DSUR, the main estimator. In the next stage, flexibility coefficients are also estimated with FGLS and PCSE models for reliability control of the model. DSUR analysis results are shown in Table 9. In the study, the lagged value of the dependent variable is also included in the model and DSUR is estimated. These results are also shown in Table 10. As seen in Table 9, renewable energy consumption, non-renewable energy consumption, capital, and trade openness have a positive and significant effect on economic growth at the level of 1% significance. A 1% increase in renewable energy consumption, non-renewable energy consumption, capital, and trade openness causes economic growth to increase by 0.084%, 0.176, 0.464, and 0.025%, respectively. The effect of energy imports on economic growth is negative and statistically significant at the 1% level. Urbanization does not affect economic growth. The analysis results in which the lagged value of the dependent variable is included in the model are similar to the results in Table 9, as shown in Table 10. The effect of variables included in the economic growth model has a similar effect. The fact that the lagged value of the dependent variable is positive and Wald χ^2 values are statistically significant at the 1% level indicates that the estimated model is appropriate. The estimation

Table 4. Cross-section dependence analysis.

Variables	GDP	RE	NRE	EI	GFC	TO	UP
Breush-Pagan LM	579.063***	1251.401***	774.044***	630.634***	575.856*	1166.391***	2044.336***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pesaran scaled LM	32.713***	79.109***	46.168***	36.272***	32.492***	73.242***	133.826***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pesaran CD	21.636***	15.515***	10.392***	1.676*	10.089***	31.955***	22.806***
	(0.000)	(0.000)	(0.000)	(0.093)	(0.000)	(0.000)	(0.000)

Note: The *p*-values are given in parentheses.*** and ∗ denote significance at %1 and %10 level, respectively.

Table 5. Slope homogeneity analysis.

	Model
$\tilde{\Delta}$	4.626***
	(0.000)
$\tilde{\Delta}_{adj}$	7.459***
	(0.000)

Note: The *p*-values are given in parentheses.*** denote significance at %1 level. Blomquist and Westerlund's (2013) slope homogeneity hac version was used.

results of FGLS and PCSE models, which take into account the cross-section dependence, are shown in Table 11. As shown in Table 11, the statistical significant of Wald χ^2 values at 1% suggests that the model estimated by FGLS and PCSE methods is the appropriate model. The coefficients of all the variables estimated in both models are statistically significant at a 1% level. According to PCSE and FGLS methods, a 1% increase in renewable energy consumption leads to a 0.084–0.130% increase in economic growth in the long run, respectively. Another finding is that the effect of non-renewable energy consumption on growth is positive. A 1% increase in non-renewable energy consumption leads to an increase of 0.176–0.210% respectively in economic growth. The energy import coefficient is estimated at −0.083 and −0.090, and the effect of energy import on economic growth is negative. This result can be interpreted as that a 1% increase in energy imports will reduce economic growth by −0.083–0.090% respectively according to PCSE and FGLS methods in the long run. The capital coefficient in the model is estimated as 0.464% and 0.453% in model order. This finding can be expressed as that a 1% increase in capital will increase economic growth by 0.464–0.453% over the long run. Table 11 shows that the effect of trade openness on economic growth is positive according to both methods. Urbanization affects economic growth positively according to the FGLS method but does not affect economic growth according to the PCSE method. When an overview of model forecasts is made, it is capital that has the most role in economic growth. Capital is followed by non-renewable energy consumption, renewable energy consumption, trade openness, and urbanization respectively. DSUR, PCSE, and FGLS prediction results are generally consistent with each other in terms of the effect of independent variables on dependent variable.

Our finding, which points to a positive relationship between renewable energy consumption and economic growth, is supported by Attiaoui et al. (2017) for 22 African countries and Shahbaz et al. (2015) for the Pakistani economy. In the existing literature, the effect of renewable energy consumption on economic growth is positive. For example, Ivanovski, Hailemariam, and Smyth (2021) find that non-renewable energy consumption is positively linked with economic growth is consistent with our empirical results. In addition, the findings of Apergis and Payne (2012) and Tugcu, Ozturk, and Aslan (2012) are in line with our findings. Our finding that non-renewable energy consumption positively affects economic growth is contradictory with Rasoulinezhad and Saboori (2018) who reported no relationship between non-renewable energy consumption and economic growth. However, in general, the direction of the relationship

Table 6. CADF and CIPS unit root analysis.

	CADF test statistic for constant		CIPS test statistic for constant		CADF test statistic for constant & trend		CIPS test statistic for constant & trend	
Variables	level	first difference	Level	first difference	level	first difference	level	first difference
GDP	−2.268**	−2.523***	−2.369**	−5.102***	−2.403	−3.064***	−2.655	−5.088***
RE	−1.439	−3.101***	−1.619	−5.424***	−1.663	−2.813**	−2.632	−5.668***
NRE	−1.554	−3.203***	−1.674	−4.526***	−2.044	−3.301***	−2.242	−4.616***
EI	−1.864	−3.226***	−1.962	−5.211***	−2.526	−3.180***	−2.527	−4.831***
GFC	−1.931	−2.370***	−1.820	−4.406***	−2.197	−2.851***	−1.850	−4.553***
TO	−1.604	−2.785***	−1.203	−5.400***	−1.569	−3.059***	−1.302	−5.464***
UP	−2.012	−2.954***	−0.686	−3.593***	−1.136	−4.743***	−0.535	−4.743***

Note: *** and ** denote significance at %1 and %5 levels, respectively.

Table 7. Pedroni, Kao, and Westerlund cointegration analysis.

	Statistic	*P*-value
Pedroni		
Modified Phillips-Perron *t*	3.1024***	0.001
Phillips-Perron *t*	−5.860***	0.000
Augmented Dickey-Fuller *t*	−5.708***	0.000
Kao		
Modified Dickey-Fuller *t*	−9.193***	0.000
Dickey-Fuller *t*	−5.357***	0.000
Augmented Dickey-Fuller *t*	−2.976***	0.001
Unadjusted modified Dickey-Fuller *t*	−10.058***	0.000
Unadjusted Dickey-Fuller *t*	−5.531***	0.000
Westerlund		
Variance Ratio	−1.9711**	0.024

Note: *** and ** denote significance at %1 and %5 levels, respectively. The cointegration tests alleviate the effect of the cross-sectional dependence structure.

Table 8. Westerlund (2007) ECM analysis.

Statistic	Value	Z-value	*P*-value
G_t	−4.439	−6.460	0.000***
G_a	−4.474	5.484	1.000
P_t	−17.081	6.597	0.000***
P_a	−5.053	3.556	1.000

Note: *** denote significance at %1.

Table 9. DSUR estimation analysis.

	DSUR	
Dependent variable: GDP	Coefficients	*P*-value
RE	0.0843264***	0.001
NRE	0.1767979***	0.000
EI	−0.0835122***	0.000
GFC	0.4640145***	0.000
TO	0.0258667***	0.000
UP	0.0147211	0.315
Constant	−20.68657***	0.000
Wald $\chi 2$	113.77	
P-value	0.000	
Observation	315	
Number of countries	15	

Note: *** and ** denote significance at %1 and %5 levels respectively.

between the variables is positive and statistically significant. In the case of 24 European countries, Marques and Fuinhas (2012) included the role of energy imports in the growth model and found that dependence on energy imports negatively affects economic growth. Their finding is consistent with our empirical results that energy imports negatively affect economic growth. Our finding that capital positively affects economic growth is similar to Zafar et al. (2019), Aslan and Altinoz (2021), and Abbas et al. (2020). Trade openness positively linked with economic growth is consistent with Wang and Zhang (2021) and Kong et al. (2021).

Table 10. DSUR analysis containing lagged value of GDP.

	DSUR	
Dependent variable: GDP	Coefficients	*P*-value
LGDP	0.2967067***	0.000
RE	0.0571112**	0.024
NRE	0.1158663***	0.000
EI	−0.0502765**	0.026
GFC	0.3007517***	0.000
TO	0.018034***	0.000
UP	0.0099949	0.496
Constant	−13.88906***	0.000
Wald $\chi 2$	137.01	
P-value	0.000	

Note: *** and ** denote significance at %1 and %5 levels respectively. LGDP shows the lagged value of the dependent variable.

Table 11. PCSE and FGLS estimation analysis.

	PCSE		FGLS	
Dependent variable: GDP	Coefficients	*P*-value	Coefficients	*P*-value
RE	0.0843264***	0.000	0.1306583***	0.000
NRE	0.1767979***	0.000	0.2102784***	0.000
EI	−0.0835122***	0.000	−0.0905916***	0.000
GFC	0.4640145***	0.000	0.4533181***	0.000
TO	0.0258667***	0.000	0.032409***	0.000
UP	0.0147211	0.309	0.0197485***	0.002
Constant	−20.68657***	0.000	−24.02735***	0.000
Wald $\chi 2$	117.63		620.34	
P-value	0.000		0.000	

Note: *** denote significance at %1 level.

Finally, the causality relationship between the variables is analyzed by applying the Dumitrescu-Hurlin causality test, and the results are reported in Table 12. We find that there is a bidirectional causality relationship between renewable energy consumption, capital, trade openness and urbanization, and economic growth. The unidirectional causality is found running from economic growth to energy imports but similar is not true from the opposite side. Thus, it is noted that energy imports have no role in economic growth.

The presence of bidirectional causality between economic growth and the renewable energy consumption is consistent with Tuna and Tuna (2019) for ASEAN countries and Sebri and Ben-Salha (2014) for BRICS countries. On the contrary, Kahia, Aïssaa, and Lanouar (2017) found a unidirectional causality relationship from economic growth to renewable energy consumption in MENA countries. Furthermore, Alam and Murad (2020) reported no causal relationship between the variables. The unidirectional causality from economic growth to non-renewable energy consumption is contrary to Samuel, Klobodu, and Apio (2018) and Gozgor, Lau, and Lu (2018) who identified the unidirectional causality relationship from non-renewable energy consumption to economic growth. However, the unidirectional causality relationship from economic growth to non-renewable energy consumption by Menyah and Wolde-Rufael (2010)

Table 12. Dumitrescu-Hurlin panel causality analysis.

Null Hypothesis	W-Stat.	Zbar-Stat.	*p*-value	Causality
RE does not cause GDP	11.239	7.642	0.000***	GDP↔RE
GDP does not cause RE	9.053	4.964	0.000***	Bidirectional Causality
NRE does not cause GDP	1.567	1.555	0.119	GDP→ NRE
GDP does not cause NRE	10.163	6.324	0.000***	Unidirectional Causality
EI does not cause GDP	1.344	0.943	0.345	GDP→ EI
GDP does not cause EI	10.635	6.902	0.000***	Unidirectional Causality
GFC does not cause GDP	10.552	6.799	0.000***	GFC↔GDP
GDP does not cause GFC	4.954	10.829	0.000***	Bidirectional Causality
TO does not cause GDP	17.620	15.457	0.000***	TO↔GDP
GDP does not cause TO	9.744	5.811	0.000***	Bidirectional Causality
UP does not cause GDP	18.573	16.624	0.000***	GDP↔UP
GDP does not cause UP	9.356	10.050	0.000***	Unidirectional Causality

Note: *** shows rejection of the null hypothesis at a 1% significance level. The optimal lag length is selected by AIC.

is consistent with our empirical findings. We find the bidirectional causality relationship from economic growth to energy imports is consistent with Bildirici and Kayikci (2022) for China, Israel, and South Korea.. The feedback effect that exists between economic growth and capital is consistent with Aslan and Altinoz (2021) and Zafar et al. (2019).

6. Conclusion and policy recommendations

This study investigated the effect of renewable energy consumption, non-renewable energy consumption, energy imports, capital, urbanization, and trade openness on economic growth in the case of 15 energy importer countries for the period of 1995–2015. The CADF and CIPS unit root tests were applied to test the stationarity properties of the variables. The cointegration relationship between the variables was examined by Kao (1999), Pedroni (2004), Westerlund (2005), and Westerlund (2007) cointegration approaches. Long-run flexibility coefficients are estimated with DSUR, PCSE, and FGLS methods. Finally, Dumitrescu and Hurlin causality test was applied to determine the causality relationship between the variables. Our results find the presence of cointegration between the variables. Further, renewable energy consumption, non-renewable energy consumption, capital, and trade openness have a positive effect on economic growth. However, energy imports have a negative effect on economic growth. Simply, it shows that renewable and non-renewable energy demand plays a positively important role in economic growth but energy imports decline in economic growth. The causality analysis reveals the existence of a bidirectional causality relationship between renewable energy consumption and economic growth. The unidirectional causality relationship is found running from economic growth to non-renewable energy consumption and energy imports. It is noted that non-renewable energy consumption and energy imports are a cause of economic growth.

All forecast results in the study revealed the negative impact of energy imports on economic growth. In the countries included in the analysis, dependence on energy imports can be considered a significant threat to energy security. To reduce this dependence, policymakers need to reconsider their current energy policies. In this context, policymakers can diversify the sources from which energy is imported, minimizing the exporter's energy supply risks and improving energy security. Thus, the development of renewable energy sources and solution proposals such as increasing energy efficiency will be beneficial to the economic growth of energy-importing countries.

Countries that can provide energy needs cheaply and uninterruptedly can not lose their production power and have the opportunity to increase and maintain international competitiveness. Energy crises that arise for various reasons at the global level negatively affect the production process and cause supply shocks. These shocks, especially those importing energy, are negatively affected. Punzi (2019) noted that fluctuations in energy prices create uncertainty about future prices. Thorbecke (2019) argued that price fluctuations affect economic activity and the behavior of economic individuals. This volatility in energy prices creates uncertain conditions regarding the cost of inputs. This reduces economic growth by affecting the investment decisions of companies and the precautionary savings of households. Renewable energy and non-renewable energy consumption positively affect economic growth. This indicates that such countries have a high dependence on energy. In particular, the positive effect of non-renewable energy demand on economic growth is greater than the positive effect of renewable energy consumption. This means that these countries are more dependent on non-renewable energy. Based on these findings, some proposals can be developed for policymakers and practitioners in 15 countries to boost economic growth. High commitment to fossil-based energy sources required for production causes high imports of the same resources in these countries. This situation also raises the problem of the current account deficit. Imports made dependent on such resources, which cause more foreign exchange outflows from countries, also negatively affect economic growth by theoretical expectations. The analysis confirms that the dependence on energy imports, which has an important place in energy policies, is a risk factor for the economy. Therefore, in addition to increasing the use of alternative energy sources such as renewable energy and increasing energy efficiency, solutions such as diversification of energy-imported resources can be beneficial to economic growth.

Note

1. Luxembourg, Japan, Ireland, South Korea, Belgium, Portugal, Italy, Turkey, Spain, Chile, Israel, Greece, Austria, Germany and Slovakia. **Source:** GlobalEconomy, Energy imports as percent of total energy use, 2015-country rankings, https://www.theglobaleconomy.com/rankings/energy_imports/.

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