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Are the effects of energy security on economic growth symmetric or asymmetric in Turkey? An application of non-linear ARDL

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ABSTRACT

This paper is examined whether the relationship between economic growth and energy security risk level is symmetric or asymmetric in the case of Turkey between 1980 and 2018. What makes different of this study from the others few studies that examine the effects of energy security on economic growth by considering the 4A of energy security is that it examines the asymmetric impacts of energy security on economic growth by using the NARDL method. Accordingly, the results of the linear ARDL demonstrate that there is no long-term relationship between energy security risk level and economic growth. On the other hand, the results of the non-linear ARDL indicate that there is an asymmetrical relationship between economic growth and energy security risk level both in the long and short-term. Furthermore, according to the NARDL results, a 1% increase in energy security risk level decreases economic growth by approximately 0.60%, while a 1% decrease in energy security risk level increases economic growth by approximately 1.72%. These results demonstrate that economic growth in Turkey is significantly affected by positive and negative changes in the energy security risk level. Therefore, the results reveal the importance of policies to ensure energy security and allow for important policy implications for policymakers.

Keywords: Energy Security, Economic Growth, Energy Policy, Non-linear ARDL, NARDL, Turkish Economy.

JEL Classification Codes: C22, O13, O40, O47, Q40.

INTRODUCTION

Energy is one of the most considerable elements in the functioning of the modern world economy. As in Peter Voser's (2012) testimony, energy is the "oxygen" of the economy and the "life-blood" of growth. At the same time, energy is one of the most important elements of social welfare. The current importance of energy has revealed the concept of energy security by making the inaccessibility to energy a nightmare of the modern world economy. At the beginning of the First World War, Winston Churchill, who was the First Lord of the Admiralty, made a historic decision by shifting from coal to oil the power supply used in ships in the British Navy. The reason for this historical decision is to make the British navy faster than the German navy, thus maintaining Britain's effectiveness on global issues. This transition meant that the Royal Navy was based not on coal in Wales but on insecure oil from Persia (Çelikpala, 2014: 79; Yergin, 2006: 69). During World War I and World War II, since oil supply to fuel warships, tanks, and fighter planes was vital, oil supply (in a sense energy security) was equivalent to national security. During the 1950s and 1960s, after the world energy demand has more than doubled, the oil-exporting countries, which are increasingly uncomfortable with the control of the international oil supply system by western companies, in a sense laid the foundations of the oil crises of the 1970s by establishing OPEC. It can be argued here that in energy security, which was previously associated with fossil fuel depletion and interrupted access to energy, a new era has begun after the oil crises of the 1970s with the addition of the affordability dimension of energy security. In this context, the oil crisis in the 1970s has also shaped the perception of modern energy security. Furthermore, increasing energy insecurity caused disturbances in oil-importing countries and led to the establishment of the IEA by OECD in 1974. Thus, the increasing importance of energy for states and societies in the historical process has revealed the concept of energy security and has made energy security a national strategy issue. Moreover, in the 1990s, the Gulf War and the fall of the Soviet Union; in the early 2000s, the 9/11 Terror Attacks, the wars in Afghanistan and Iraq, the Arab Spring Events, and attacks by terrorist organizations as the DEAS have led to further tensions and instability in the perception of energy security. Finally, the Covid-19 pandemic and the continuing effects of the Russia-Ukraine War have revealed a significant break in the perception of global energy

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security. Moreover, it can be also argued that the effects of this transformation have the potential to produce different results. On the other hand, developments such as the institutionalization of global warming problems and increased awareness of climate change troubles have revealed the acceptability dimension of energy security, whose importance is increasing day by day. Thus, energy security together with what has happened in the historical process has become a multi-dimensional concept that it is included the dimensions expressed as 4A's, which availability, affordability, accessibility, and acceptability (Energy Charter Secretariat, 2015: 6-8; Kartal, 2020: 82-85). In this context, what the 4A of energy security means, the risks it includes, and the solution proposals for these risks are summarized in Table 1. Accordingly, the main factor shaping the energy security perception of countries is the "availability" dimension of energy security, which means having energy resources. Due to the unbalance geographical distribution of resources in the world, while energy resources have abundant in some countries, these resources either do not have or have inadequate in some countries. In other words, the current status of a country in terms of the "availability" dimension of energy security also shapes the value and meaning of other dimensions of energy security in that country, which are affordability, accessibility, and acceptability.

Table 1. Dimensions of Energy Security for Countries

Dimension		For Exporter Country	For Importer Country
Availability	The meaning of dimension	It has more than its own needs in terms of energy resources. Therefore, it exports the portion of production exceeding consumption.	Energy sources are absent or too low to meet consumption. It has to imports.
	Potential risks	• Field safety of energy resources. • High dependence of the economy on revenues from energy exports.	• Highly dependent on imports in energy. • The use of energy as a weapon in international relations. (If you do not/do not give, I will cut off the gas, you will feel cold)
	Policy Recommendations	• Security measures should be taken (requires cost). • Diversity in economic activities should be ensured by directing the revenues from energy exports to new investments.	• Resource diversification (the use of renewable energy sources), energy efficiency, and energy-saving: reduces the degree of dependency. • Country diversification: possible risks are reduced thanks to imports from alternative countries (If you cut the gas, I buy it from another country).
Affordability	The meaning of dimension	The prices in the energy market must be more (or at least equal) than costs such as extraction, transportation, and refining of energy sources. (price≥-cost=profitability).	The price of imported energy must be affordable.
	Potential risks	• If the price of the energy source is below the cost, production will not be profitable. Therefore, there is no importance of "availability" of energy sources, export of energy resources also not be profitable (So, negative profit from exports). • If the country's economy is highly dependent on energy revenues, fluctuations in energy prices (decreases) will instability the country's economy.	• If the country's economy is highly dependent on energy imports, fluctuations in energy prices may make the country's economy unstable. • Since energy imports are in foreign currency, fluctuations in the exchange rate may also affect access to energy at an affordable price.
	Policy Recommendations	• The following policies can be implemented: a) If the country's production level is strong enough to control price movements, it can reduce supply and increase prices to an optimal level. (This usually requires to compromise with other energy importers) b) If the quality of the product is low, energy needs must be met through imports rather than production (So, the country has been an importer, not an exporter). c) If the product is of good quality, production costs should be reduced with new production techniques; if this is not possible, it should be preferred to bear this cost instead of dependence on imports (This extra cost is preferable, as dependence on imports will cause another risk.) • Diversity in economic activities: Policies to reduce the share of energy revenues in exports should be produced, and diversification should be made in export products by investing in sectors with high added value.	• A diversification policy should be applied: a) Resource diversification (the use of renewable energy sources), Energy efficiency, energy saving: It provides to meet energy needs from more suitable sources. b) Country diversification: By reaching more exporters, it provides access to the most cost-effective energy source among the alternatives. It also gives bargaining power. • The implementation of monetary policies aimed at stability in the exchange rate. • Trading in local currency by developing mutual trade relations with energy importer countries.

Dimension		For Exporter Country	For Importer Country
Accessibility	The meaning of dimension	It means uninterrupted access to existing resources.	It means uninterrupted access to resources through imports.
	Potential risks	• The field security of energy resources. • The security of distribution channels. • The security of transition routes.	• The security of transition routes in imports. • Disruption of energy flow because of problems that have been experienced or are likely to occur with exporting countries for political, military, economic, etc. reasons or natural causes (Energy can use as a weapon).
	Policy Recommendations	• Taking deterrent security measures. • Using high-security modern distribution channels. • Implementing diversification policies: • Choosing safe routes. • Diversification of transition routes.	• Safe routes must be preferred when determining crossing routes. • Diversification policies should be implemented to can be engaged different alternatives as a precaution for possible problems: a) Diversification of country in imports. b) Diversification of distribution channels (Pipeline, ship, and tanker transportation). c) Diversification of crossing routes.
Acceptability	The meaning of dimension	Environmental effects of energy consumption.	
	Potential risks	Intensive consumption of energy increases carbon emissions endangering natural life and human life (health): • Climate change. • Air pollution. • Ecological deterioration. • Water pollution. • Soil pollution. • Traffic jam. • Depletion of resources due to excessive consumption. • Accidents that have occurred/are likely to occur during the energy transport by sea, tanker, or pipeline	
	Policy Recommendations	• Implementing policies to reduce fossil fuel consumption: a) Increasing renewable energy consumption. b) Energy efficiency. c) Energy-saving. • Establishing modern distribution channels and transportation networks to minimize risks; making legal arrangements to protect the environment in energy trade and consumption.	

Source: Prepared by the author.

The concept of energy security, which was previously evaluated to a few dimensions, has been expanded to include issues such as environment, governance, and energy efficiency by increasingly being integrated. Azzuni and Breyer (2018), on the other hand, have examined energy security in fourteen dimensions by analyzing the concept of energy security from a wider perspective. In this context, the concept of energy security is a very comprehensive concept with 14 dimensions and 42 parameters. On the other hand, Sovacool and Mukherjee (2011) created a broad synthesis by dividing energy security into five dimensions (availability, affordability, technology development, sustainability, and regulation), these five dimensions into 20 components, and these components into 320 simple indicators and 52 complex indicators. On the other hand, as with many concepts, there is no consensus on the definition of energy security. In line with this, Sovacool and Mukherjee (2011) state that they have identified 45 different definitions of energy security. Based on Table 1, the fact that the meaning and importance of energy security are different for each country also leads to the emergence of many definitions of energy security. Because every country has made sense of energy security by considering current conditions. In this context, according to the definition of IEA (2020), which is one of the most concise definitions of energy security, energy security is the uninterrupted availability of energy sources at an affordable price. This definition is quite important in terms of forming the essence of the concept of energy security. However, this definition of energy security includes the 3A of energy security including availability, affordability, and accessibility, and reflects the classical energy security perception. Therefore, this definition of IEA's energy security has been expanded in a study by Kartal (2022a) as "the uninterrupted availability of energy sources at an affordable price in accordance with the environment and social welfare". Thus, the definition of energy security has been restated to include the 4A of energy security by adding the acceptability dimension of energy security to the definition in question.

In this respect, the fact that energy security is a multidimensional concept causes both to affect many areas and be affected by many areas. In this direction, energy security can be expected to both affect the economy and be affected by economic conditions. It can be argued that the fact that energy is the most considerable input of the modern world economy reveals the necessity of a serious examination of the economic effects of energy security. Furthermore, many macro-economic variables are affected differently by positive and negative shocks, and therefore it is necessary to examine these effects with non-linear methods as well as linear methods. Therefore, this study investigates the relationship between economic growth and energy security in Turkey by using both linear ARDL and non-linear ARDL methods. In this context, the main motivation of this study is to reveal the first study examining the relationship between economic growth and energy security with both linear and non-linear approaches. Moreover, the other motivations of this study are to reveal the fact whether positive shocks or negative shocks in energy security have a greater impact on economic growth in Turkey, to arise the importance of energy security in Turkey, and to present a projection for energy security for policymakers in this direction. Accordingly, in the next part of the study, Turkey's situation in terms of energy security is analyzed by presenting some statistical data within framework 4A of energy security. Then, the literature on the relationship between energy security and economic growth is examined. In the next section, the empirical method and methodology to be used in the study are introduced. Finally, the findings obtained from the empirical applications on the relationship between energy security and economic growth in Turkey are reported and interpreted, and then policy recommendations are made in line with the findings obtained.

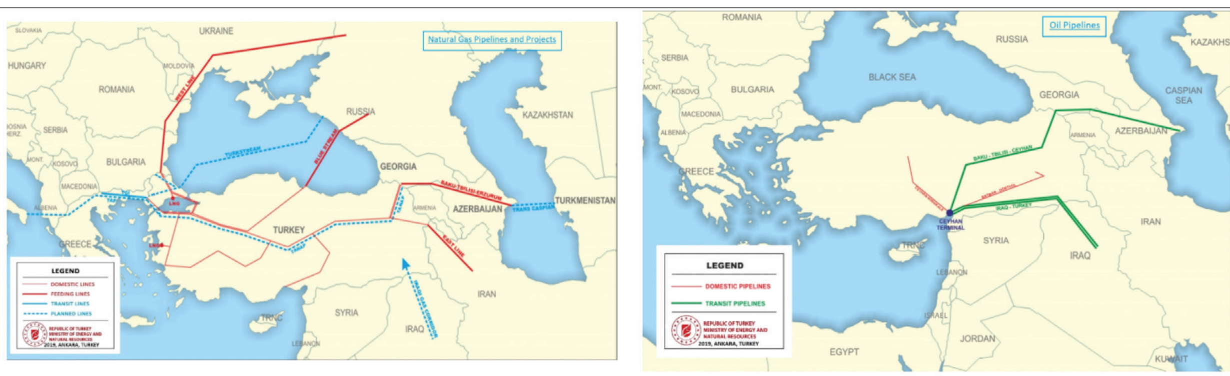
Energy Security in Turkey

When Turkey's situation in terms of energy security is evaluated, it should first be started with the availability of energy security, which significantly determines the meaning and importance of the other dimensions of the 4A's of energy security. As stated before, the most important energy security dimension that determines the meaning and importance of energy security for countries is availability. In this context, Turkey is not a self-sufficient country in energy but is dependent on external energy suppliers. This demonstrates that Turkey's situation in terms of energy security dimensions should be evaluated according to the points given for the importing countries in Table 1, where the meaning and importance for the countries are given. Accordingly, the degree of dependence on energy imports is one of the most important factors affecting the energy security risk level. According to Trade Map (2021) data, total energy imports for Turkey are $50.7 billion in 2021. While the share of energy imports in the total import share is 18.7%, worldwide this rate is 11.7%. In this context, it can be argued that the share of Turkey's energy imports in total imports is above the world average, increasing Turkey's risk level in terms of this dimension of energy security. The reduction of energy security risks by countries with foreign dependence on energy depends on country diversification. According to Kartal (2022a), occupies Russia 31%, Iran 13%, and Azerbaijan 4% of energy imports in Turkey, while the majority of the remaining imports are made from other Middle Eastern countries. These three countries account for 48% of Turkey's energy imports. Accordingly, Turkey's low country diversification in energy imports constitutes an important energy security risk. The risk of a major energy access problem may arise in possible problems with countries with a high degree of energy dependence, similar to the risk that arose in the bilateral problem with Russia due to Turkey's downing of the Russian warplane. As a result, such situations can significantly affect the accessibility dimension of energy security.

Moreover, Turkey's high dependence on energy and the fact that its energy imports are limited to a few countries arise significant risks in terms of affordability, which is another dimension of energy security. In this direction, it is clear that the effect of the increase in oil and natural gas prices after the Russia-Ukraine War creates a quite important energy security risk. The ongoing consequences of this emerging situation in the Turkish economy have once again demonstrated the importance of the affordability aspect of energy security. The affordability dimension of energy security in the Turkish economy is significantly affected by fluctuations in energy prices as well as by changes in exchange rates. In this direction, it can be argued that both fluctuations in oil prices and increases in exchange rates have adversely affected the Turkish economy in terms of the affordability of energy security. In this context, renewable energy resources are the most important factor that significantly affects both the availability and affordability aspects of energy security for countries with insufficient resources in terms of fossil fuels. In this direction, when looking at the distribution of energy consumption in Turkey according to energy sources, according to BP (2021) data, while primary energy consumption is 144.39 million tonnes of oil equivalent, renewables energy is 5.374 million tonnes of oil equivalent. According to these data, most of the energy consumption (approximately 97%) comes from fossil fuels. This situation possesses both an important energy security risk for Turkey and offers significant opportunities. In this respect, the most important risk is that resource diversification in terms of energy resources is limited to fossil fuels. Due to the inadequacy of resources in terms of fossil fuels in Turkey, this situation may cause an increase in foreign dependency on energy and may bring risks that may negatively affect the availability and affordability dimensions of energy security. On the other hand, the most important opportunity arising from the quite low level of renewable energy consumption is the existence of the potential to reduce the energy security risk level, thanks to increasing the share of renewable energy in energy consumption. This opportunity stems from the fact that Turkey has not yet reached the limits of its current potential in renewable energy. Moreover, another important contribution to the energy security of an increase in the consumption of renewable energy sources is positive effects on the affordability dimension of energy security, which is becoming increasingly important.

Another important factor that determines the position of Turkey in terms of energy security is the geopolitical position of Turkey, in terms of having important transition points (straits and pipelines). The strategic geographical position of Turkey between producer countries and consumer countries can provide a safe and sustainable route, which contribute to energy security by transporting the neighboring resources to Turkey and world markets through Turkey stably and securely. Turkey's this potential is contained quite significant opportunities for energy security. For example, Turkey has the opportunity to provide energy security of both its own and the countries it mediates in energy trade position by making both countries and crossing route diversification in energy imports. Thus, Turkey can both take great strides toward being a strategic energy corridor and strengthen its position in international political competition. For this purpose, projects based on a win-win relationship and provided mutual benefits are being implemented (Republic of Turkey Ministry of Energy and Natural Resources, n.d.). Some of the pipeline projects implemented for this purpose are demonstrated in Figure 1.

Briefly, some of the factors that increase Turkey's energy security risk are high dependence on imports in energy due to inadequate resources, the fact that resource diversity in energy consumption is limited to fossil fuels, risks arising from both energy price fluctuations and exchange rate fluctuations, low country diversification in energy imports, and finally environmental risks arising from the low share of renewable energy consumption in total energy consumption.



Natural Gas Pipelines and Projects:
- Russian-Turkey Natural Gas Pipeline (West Line)
- Blue Stream Gas Pipeline
- Eastern Anatolian Natural Gas Main Transmission Pipeline (Iran - Turkey)
- Baku-Tbilisi-Erzurum Natural Gas Pipeline
- Turkey-Greece Natural Gas Interconnection
- Trans-Anatolia Natural Gas Pipeline Project
- Turkish Stream Gas Pipeline

Oil Pipelines:
- Iraq-Turkey Crude Oil Pipeline
- Baku-Tbilisi-Ceyhan Crude Oil Main Export Pipeline

Figure 1. Oil and Gas Pipelines in Turkey
Source: Republic of Turkey Ministry of Energy and Natural Resources.

Literature Review

Although, there is a large empirical literature focusing on energy security, most of studies on energy security focus on:

- Focusing on the dimensions of energy security, factors affecting energy security, or the current case of countries (see. Yao & Chang, 2014; Li, Shi & Yao, 2016; Yao, Shi & Andrews-Speed, 2018; Bambawale & Sovacool, 2011; Wang & Zhou, 2017; Song, Zhang & Sun, 2019; Sovacool & Mukherjee, 2011; Zhang, 2011; Kim, Shin & Chung, 2011; Kruyt et al., 2009).
- Focusing on the economic effects of energy security through a few variables such as fuel supply, natural gas consumption, electricity availability, environmental stress (see. Balitskiy, Bilan & Strielkowski, 2014; Nepal & Paija, 2019; Varigonda, 2013; Ahmed et al., 2019; Gasparatos & Gadda, 2009).
- Focusing on the economic effects of energy price shocks, which is only one dimension of energy security (see. Alley, Asekomeh, Mobolaji, & Adeniran, 2014; Bernanke, Gertler, Watson, Sims, & Friedman, 1997; Berument, Ceylan, Dogan, The, & Journal, 2016; Doroodian & Boyd, 2003; Du, Yanan, & Wei, 2010; Elder & Serletis, 2010; Farzanegan & Markwardt, 2009; Ghalayini, 2011; Jiménez-Rodríguez & Sánchez, 2005; Kilian & Park, 2009; Sadorsky, 1999; Tang, Wu, & Zhang, 2010; D. Zhang, 2008).

However, few studies focus on energy security, which means the uninterrupted availability of energy sources at an affordable price and including the entire 4A of energy security, such as access to energy, energy consumption, carbon emissions, renewable energy, energy prices. The first of these studies is the study by Kartal (2018) and Kartal & Öztürk (2020) that was examined the relationship among political instability, energy security, and growth by using data obtained from fifteen Middle Eastern countries between the years 1996 and 2014. As a result of econometric analysis, the author stated that a long-term relationship between the variables was determined. The results from the FMOLS estimator demonstrate that while a 1% increase in energy security risk was decreased GDP per capita by 0.41%, a 1% increase in political stability was increased GDP per capita by 0.25%. In addition, according to the results obtained from the Panel Granger Causality Analysis in this study, there is a bi-directional association between energy security and GDP per capita and, a unidirectional causality relationship from energy security to political stability and from GDP per capita to political stability.

Another study, which focuses on energy security, is by Stavytsk et al. (2018). In this study, an empirical analysis was performed for 29 European countries covering the years 1997-2016 with the help of an index (the New Energy Security Index) created by the authors. According to the findings obtained as a result of the study, it was stated by the authors that the increase in GDP positively correlated with NSI, and negatively with CPI.

Fang et al. (2018) was proposed five dimensions of energy security, which availability, accessibility, affordability, acceptability, and developability, to construct China's Sustainable Energy Security (CSES) evaluation index model. Moreover, in this study, an empirical study of China's energy security is carried out with data from 2005 to 2015 by using this proposed model, and dynamic changing trends are analyzed. Based on the results obtained, the authors argue that availability and develop-ability are the most important weights in China's Sustainable Energy Security index system, where availability demonstrate a general downward trend, and develop-ability presents an inverted U-type trend, with its lowest point in 2011. In addition, the authors state that from 2008 to 2012, China's sustainable energy security had been at risk.

In a study by Le and Nguyen (2019), the relationship between energy security and growth was examined by using ten measures of energy security, which five aspects of energy security including availability, accessibility, affordability, and developability, with a data set covering 74 countries from 2002 to 2013. According to the authors, the results demonstrate that energy security increases economic growth for both all sample countries and sub-samples. In addition, according to the authors, energy insecurity is measured by the variables of energy density and carbon density, which negatively affect economic growth. The findings demonstrate that these three factors are interconnected in the economic development, energy security and climate change mitigation at the global level, so integrated policies should be followed.

Kartal (2022a) examined the relationship between energy security and growth between 1992 and 2016 in the Turkic World countries including Turkey, Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan by using the Panel Durbin-Hausman Cointegration Test and the AMG estimator. In this study is concluded that a 1% increase in energy security risk level in the Turkic World countries reduces the economic growth by approximately 0.95%. According to the results obtained from the AMG estimator for Turkey in the study, a 1% increase in energy security risk level in Turkey reduces the economic growth by approximately 1.98%. Another study conducted by Kartal (2022b) examined the causality relationship between energy security and economic growth for 74 countries from different income groups by using the Kónya (2006) Bootstrap Panel Causality test. In this study, it is determined that there is bidirectional causality for 22 countries, there is no causality for 18 countries, there is unidirectional causality from energy security risk level to GDP for 14 countries and from GDP to energy security risk level for 20 countries. Moreover, according to the results obtained for Turkey, there is unidirectional causality from GDP to energy security risk level. Moreover, the causality relationship between energy security and growth in Turkey between 1980 and 2018 was examined using the Hatemi-J Asymmetric Causality Test by Kartal (2022c). In this study has been determined that there is a uni-directional causality from the increase in the energy security risk level (i.e., positive shocks) to the decrease in GDP (i.e., negative shock).

In this context, when the literature on the subject is evaluated in general, it is seen that there are few studies examining the effects of energy security on economic growth by considering the 4A of energy security and the existing studies examine a narrow period. The countries/regions subject to the analysis are Middle Eastern countries, Europe, Turkic World countries, and China. All three studies involving Turkey use panel data analysis techniques. Therefore, there is no empirical study focusing specifically on Turkey. Moreover, the entire empirical methods used are methods that give symmetrical results for energy security, and there is no study examining the different effects of positive and negative shocks in energy security on economic growth. In addition, existing studies provide evidence that the energy security risk level significantly affects the economic growth of countries.

As a result of the literature review carried out, it is determined that the data regarding the existing studies on the subject are short periods, there is not a study on Turkey, the possible different effects of positive and negative shocks in energy security on economic growth are not taken into account. In this direction, this study aims to eliminate these deficiencies stated in the literature.

Data and Methodology

This manuscript investigates whether the relationship between economic growth and energy security risk level is symmetric or asymmetric in the case of Turkey between 1980 and 2018. For this purpose, empirical analysis is performed by using linear ARDL and non-linear ARDL methods. In the study, the International Energy Security Risk Index (ESRI) published by the Global Energy Institute is used as the energy security risk variable. In measuring energy security, indexes obtained by combining a large amount of data on the dimensions of energy security are frequently used. One of these indexes is the Energy Security Risk Index published by the Global Energy Institute, which is also used in this study. This index consists of 8 main themes and 28 sub-themes containing a large amount of data on the dimensions of energy security[1.] Accordingly, when the variables used in the index are examined, it is seen that the index includes many variables covering all dimensions of energy security. Therefore, the fact that the index contains data on many aspects of energy security provides that can be obtained important information about a country's energy security structure by looking at Energy Security Risk Index. Furthermore, the use of this index as an energy security risk variable in empirical analyzes to energy security can provide to be the subject of empirical analysis of all aspects of energy security. For this reason, this stud is used the International Energy Security Risk Index (ESRI) published by the Global Energy Institute as an energy security risk variable. GDP data, another variable used in the study, was obtained from the Penn World Table (2020). Empirical analysis has been conducted by using natural log transformations of variables. The factor determining the research period of the study is that the ESRI data in the relevant database for Turkey started in 1980 and ended in 2018. Therefore, the empirical analysis covers the period 1980 to 2018.

In the study, while the linear relationship between economic growth and energy security is examined by the Autoregressive Distributed Lag (ARDL) Bound Test approach proposed by Pesaran et al. (2001), the non-linear relationship between the variables is examined with the Non-linear Autoregressive Distributed Lag (NARDL) Bound Test approach, which is an extended version of the ARDL method and proposed by Shin et al. (2014). The significant advantage of the ARDL bound test is that it can be used even if the variables are integrated

[1] For details on Energy Security Risk Index Variables, see Global Energy Institute (2018: 71-75).

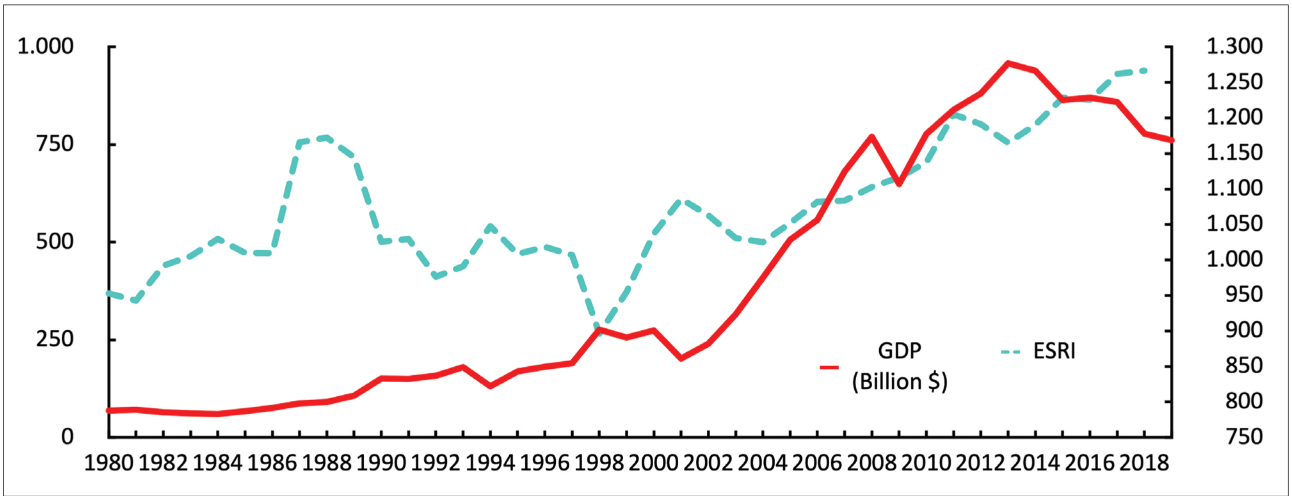


Figure 2. Energy Security Risk Index and GDP in Turkey (1980-2016)
Source: World Bank (2021); Global Energy Institute (2020).

to different degrees, i.e., irrespective of whether the regressors are I(0) or I(1). Thus, significant flexibility is provided in the analysis of the long-term relationship between the variables. On the other hand, many macroeconomic variables are non-linear, as also stated by Shin et al. (2014). Therefore, the NARDL approach, which allows to detection of different effects of negative and positive shocks in the independent variable on the dependent variable, provides an extra contribution according to ARDL. Thus, the obtained results allow different and important inferences for policymakers.

In obtaining ARDL and NARDL methods procedures have been followed methodological representation given by Ullah et al (2021). Accordingly, the linear model for the cointegration relationship between economic growth and energy security is denoted in Eq. (1):

$$\ln gdp_t = \varphi_0 + \varphi_1 \ln esri_t + \varepsilon_t \qquad (1)$$

where lngdp, lnesri, and ε_t represent economic growth, energy security risk index and residual term, respectively. The linear model is given in Eq. (1) is transformed into non-linear model as denoted in Eq. (2):

$$\ln gdp_t = \varphi_0 + \varphi_1 \ln esri_t + \varepsilon_t \qquad (2)$$

where φ_i, $\ln esri_t^+$ and $\ln esri_t^-$ represent long-term coefficients vector, the partial sum of positive changes in $\ln esri$ and the partial sum of negative changes in $\ln esri$, respectively. Accordingly, the partial sums of positive and negative changes in $\ln esri$ can be also denoted as:

$$\ln esri_t^+ = \sum_{i=1}^{j} \Delta \ln esri_t^+ = \sum_{i=1}^{j} \max(\Delta \ln esri_j, 0) \qquad (3)$$

$$\ln esri_t^- = \sum_{i=1}^{j} \Delta \ln esri_t^- = \sum_{i=1}^{j} \max(\Delta \ln esri_j, 0) \qquad (4)$$

The NARDL model is obtained by rearranging Eq. (2) as recommended by Pesaran et al. (2001) and Shin et al. (2014). Accordingly, the asymmetric ARDL model obtained is denoted in Eq.(5):

$$\begin{aligned}\Delta \ln gdp_t = {} & \varsigma_0 + \varsigma_1 \ln gdp_{t-1} + \varsigma_2^+ \ln esri_{t-1}^+ + \varsigma_3^- \ln esri_{t-1}^- \\ & + \sum_{i=1}^{p} \phi_{1i} \Delta \ln gdp_{t-i} + \sum_{i=0}^{q} \phi_{2i}^+ \Delta \ln esri_{t-i}^+ + \sum_{i=0}^{m} \phi_{3i}^- \Delta \ln esri_{t-i}^- + \varepsilon_t\end{aligned} \qquad (5)$$

where p, q, m is represented lag orders. In Equation (5), the long-term positive and negative effects (i.e., φ_1 for positive shocks and φ_2 for negative shocks) in ESRI on GDP given in Equation (2) are denoted to:

$$\varphi_{\ln esri^+} = -\varsigma_2^+ / \varsigma_1 \quad and \quad \varphi_{\ln esri^-} = -\varsigma_3^- / \varsigma_1 \qquad (6)$$

On the other hand, the short-term positive and negative effects in ESRI on GDP are denoted to:

$$\ln esri^+ = \sum_{i=0}^{q} \phi_{2i}^+ \quad \text{and} \quad \ln esri^- = \sum_{i=0}^{q} \phi_{3i}^- \qquad (7)$$

The next part of the study performed empirical application, and the empirical process proceeds as follows: Before performing ARDL and NARDL tests, it is necessary to determine the integration degrees of the variables. Because according to the model specification both ARDL and NARDL, the variables should not be integrated in the second order. In this direction, in the empirical analysis, firstly, the ADF unit root test and the KPSS stationarity test are performed to determine the integration degrees of the variables. Then, ARDL and NARDL bound tests are performed to investigate the long-term relationship between the variables. Afterward, some diagnostic tests are performed on the validity of the obtained results and the model. Accordingly, it is being tested whether the variables have a normal distribution with the Jarque-Bera normality test; whether there is autocorrelation in the model with the Breusch-Godfrey LM Test; whether there is a problem of heteroskedasticity in the model with the ARCH test; the stability of model specification with the Ramsey Reset Test, CUSUM, and CUSUMSQ tests; and whether long-term and short-term asymmetric relationship hold between variables with Wald Test. Finally, coefficient estimation for both the short-term and the long-term is performed by using the NARDL model.

Empirical Results

Since variables should not be integrated in the second order in both ARDL and NARDL models, the empirical analysis should begin by checking this precondition. Therefore, variables have been analyzed using both the Augmented Dickey–Fuller (ADF) unit-root test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) stationarity test. In this context, according to the ADF unit-root test results, while the null hypothesis (variables have a unit-root) cannot be rejected at the level in both the constant model and the constant and trend model (see, Table 2), it is rejected at the first difference (see, Table 3).

On the other hand, according to the KPSS stationarity test results, while the null hypothesis (variables have stationary) is rejected at the level in both the constant model and the constant and trend model (see, Table 2), it cannot be rejected at the first difference (see, Table 3). Therefore, both test results indicate that while variables have a unit root at the level, they are stationary when the first differences of the variables are taken.

Results validate that both variables are I(1), and allow for the application of ARDL and NARDL methodology. Accordingly, the ARDL and NARDL Bound Test results performed are given in Table 4. The model given in Equation 1, which was designed to determine the long-term linear relationship between the variables, has been estimated by the ARDL method. Since the F-statistics value is lower than corresponding the upper and lower bounds, it has been concluded that there is no linear relationship between economic growth and energy security in the long-term.

On the other hand, the model given in Equation 5, which was designed to determine the long-term non-linear relationship between the variables, has been estimated by the non-linear ARDL method. Since the

Table 2. Unit Root Test Results (Level)

Variables	Constant		Constant and Trend	
	ADF	KPSS	ADF	KPSS
lngdp	0.372	3.724***	-1.366	0.660***
lnesri	-1.385	1.964***	-2.192	0.455***
Critical Values	%1: -3.590 %5: -2.925 %10 -2.594	0.718 0.473 0.353	-4.194 -3.515 -3.185	0.212 0.149 0.122

Note: The optimal lags length has been determined by the max 3 lag and SIC for the ADF unit root tests. Long-term consistent variance estimation method has been determined by Bartlett method for KPSS unit root tests. ***, **, * indicates statistical significance at 1%, 5% and 10%.

Table 3. Unit Root Test Results (First Difference)

Variables	Constant		Constant and Trend	
	ADF	KPSS	ADF	KPSS
Δlngdp	-6.355***	0.145	-6.454***	0.080
Δlnesri	-5.741***	0.066	-5.663***	0.050
Critical Values	%1: -3.596 %5: -2.927 %10: -2.595	0.718 0.473 0.353	-4.203 -3.519 -3.187	0.212 0.149 0.122

Note: The optimal lags length has been determined by the max 3 lag and SIC for the ADF unit root tests. Long-term consistent variance estimation method has been determined by Bartlett method for KPSS unit root tests. ***, **, * indicates statistical significance at 1%, 5% and 10%.

Table 4. ARDL and NARDL Cointegration Test Results

Model	F-Stat.	Critical Values						Decision
		1%		5%		10%		
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
ARDL (1.0)	1.735	10.150	11.230	7.135	7.980	5.915	6.630	Accepted
NARDL (4.1.4)	9.298***	7.643	9.063	5.457	6.570	4.517	5.480	Rejected

Note: The optimal lag length was determined by the AIC information criterion. ***, **, * indicates statistical significance at 1%, 5% and 10%.

Table 5. Non-linear ARDL Test Results

Variable	Coefficient	Std, Error	t-Statistic	*p*-value
lngdp(-1)	-1.117	0.221	-5.046	0.000
$lnesri^{(+)}_{t-1}$	-0.673	0.284	-2.372	0.027
$lnesri^{(-)}_{t-1}$	1.918	0.421	4.555	0.000
$\Delta lngdp_{t-1}$	0.431	0.189	2.278	0.033
$\Delta lngdp_{t-2}$	0.319	0.182	1.753	0.094
$\Delta lngdp_{t-3}$	0.288	0.165	1.742	0.096
$\Delta lnesri^{(+)}$	-0.003	0.299	-0.012	0.991
$\Delta lnesri^{(-)}$	0.442	0.315	1.404	0.175
$\Delta lnesri^{(-)}_{t-1}$	-0.740	0.452	-1.636	0.117
$\Delta lnesri^{(-)}_{t-2}$	-0.767	0.381	-2.012	0.057
$\Delta lnesri^{(-)}_{t-3}$	-0.776	0.323	-2.407	0.025
c	14.142	2.787	5.075	0.000
trend	0.094	0.018	5.221	0.000
R^2	0.995			
Adj R^2	0.993			
D-W	2.219			
F-statistics	1,215.812			0.000
Jarque-Bera normality	2.101			0.350

Note: The optimal lag length was determined by the AIC information criterion.

F-statistics value is higher than corresponding the upper and lower bounds, it has been concluded that there is a non-linear relationship between economic growth and energy security in the long-term, unlike the linear ARDL model. Accordingly, the non-linear ARDL estimation results are given in Table 5.

Although an asymmetric relationship between economic growth and energy security has been identified in the long-term by using NARDL Bound Test, more evidence is needed to confirm the asymmetries, both in the long-term and the short-term. For this purpose, the Wald test is frequently used in the literature. Accordingly, the results of the Wald test performed in this study are given in Table 6. According to the results obtained, the null hypothesis indicating that there are no asymmetries in both the long-term (at 1% significance level) and the short-term (at 10% significance level) is rejected. Accordingly, it was concluded that the relationship between economic growth and energy security is asymmetric in both the short-term and the long-term.

Some diagnostic check tests have been made for the validity of the results obtained, and the results are given in Table 7. Accordingly, it is concluded that there is no autocorrelation in the model with the Breusch-Godfrey LM Test, there is no problem of heteroskedasticity in the model with the ARCH test, and model specifications are

Table 6. Wald Tests

Null Hypothesis	F-Statistic	*p*-value	Results
No long-term asymmetry	23.904***	0.000	Rejected
No short-term asymmetry	1.741*	0.096	Rejected

Note: ***, **, * indicates statistical significance at 1%, 5% and 10%.

Table 7. Diagnostic Check Tests

Diagnostic tests	χ_1^2	χ_2^2	χ_3^2	χ_4^2
Breusch-Godfrey LM Test	1.504	0.729	1.087	0.821
	(0.234)	(0.496)	(0.380)	(0.530)
ARCH Test	1.775	0.972	0.737	0.733
	(0.192	(0.391)	(0.539)	(0.578)
Ramsey Reset Test	1.663	1.316	0.844	1.436
	(0.112)	(0.292)	(0.488)	(0.265)

Note: Values in parentheses denote probability values.

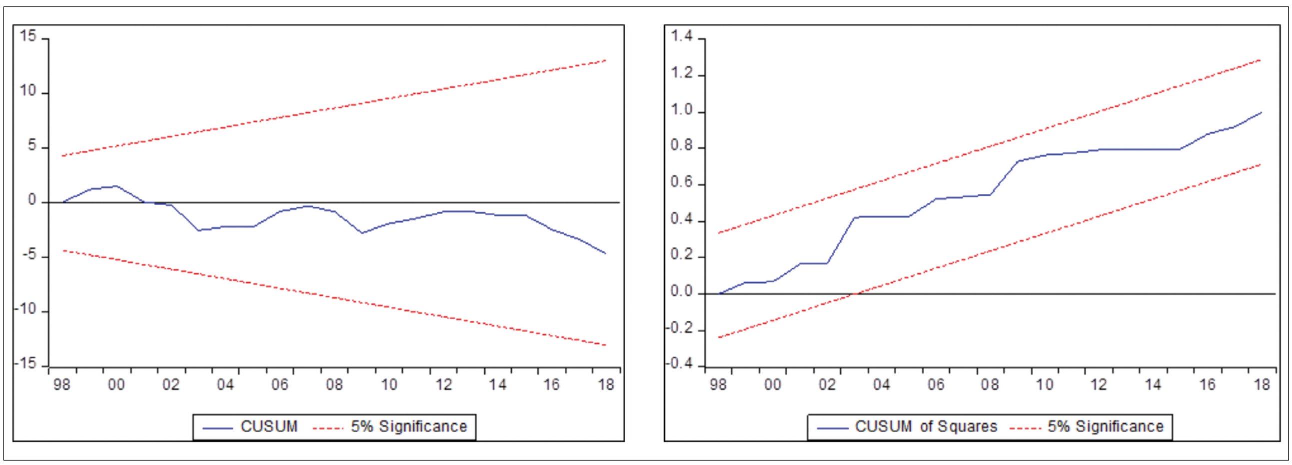


Figure 3. CUSUM and CUSUMSQ

stable with the Ramsey Reset Test. Moreover, according to CUSUM and CUSUMSQ test results given in Figure 3, the model is stable.

After confirming the validity of the results of the model specifications, both the long-term and short-term coefficient results of the NARDL model for Turkey are given in Table 8. According to the long-term NARDL coefficient estimation results, a 1% increase in energy security risk level (that is, a negative situation in energy security) decreases economic growth by approximately 0.60%, while a 1% decrease in energy security circus level (that is, a positive situation in energy security) increases economic growth by approximately 1.72%. In other words, there is an inverse relationship between energy security

Table 8. The Long-term and Short-term Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
lnesri$^{(+)}$	-0.603	0.262	-2.299	0.032
lnesri$^{(-)}$	1.718	0.140	12.264	0.000
Δlnesri$^{(+)}$	-0.025	0.300	-0.083	0.935
Δlnesri$^{(-)}$	0.175	0.325	0.537	0.596
ECT_{t-1}	-0.764	0.280	-2.728	0.011

risk levels and economic growth in the long-term. Moreover, negative shifts in energy security risk levels have a stronger effect than positive shifts.

According to the results obtained from the short-term analysis, the coefficient of the Error Correction Model (ECT) is negative and significant at the 1% significance level, and the results confirm that the model running. In this direction, while approximately 76.4% of a short-term deviation disappears in a single period, it converges to a long-term equilibrium level in 1.3 periods. Similar to the long-term, there is an inverse relationship between energy security risk levels and economic growth in the short-term. However, the short-term results are statistically insignificant, contrary to the long-term results.

Results and Discussion

This study has examined whether the relationship between economic growth and energy security risk level is symmetric or asymmetric in Turkey between 1980 and 2018 by using linear and non-linear ARDL methods. The findings indicate that the relationship between economic growth and energy security risk level is not symmetric but asymmetric. Accordingly, it has been concluded that a 1% increase in energy security risk levels decreases economic growth by approximately 0.60%. In other words, the factors that increase energy security risk levels in Turkey cause economic contraction. Considering the fact that the dependence of production processes on energy is high in modern economies, it can be argued that the increased risks in terms of access to energy increase the risks in production processes and cause economic contraction with this link. On the other hand, another result obtained from the NARDL test indicates that a 1% decrease in energy security risk level increases economic growth by approximately 1.72%. This result implies that the factors that reduce the energy security risk level also activate economic growth. Considering that energy is one of the most considerable inputs of the modern production process, it can be argued that the reduction of risks in energy security encourages economic growth by arising a series of positive (direct and/or indirect) effects that facilitate the production process. Accordingly, economic growth is affected by both increases and decreases in the level of energy security risk. Moreover, it is quite notable that the effect of a downward shift in energy security risk levels (in other words, increased energy security) on economic growth has a stronger effect than an upward shift in energy security risk levels (in other words, decreased energy security). As a result, reducing the energy security risk level in the Turkish economy will both directly contribute to economic growth and prevent economic contractions risk due to the increase in the energy security risk level. Therefore, it can be argued that ensuring energy security is quite a considerable issue in the Turkish economy, and policymakers should produce policies in this direction. In this context, factors that negatively affect or are likely to affect energy security in Turkey should be determined, and policies should be developed to eliminate these risk factors.

When Turkey is evaluated in terms of energy security risk factors, it is seen that there is a high foreign dependence on energy and, the considerable risks arising from this dependence. These risk factors negatively affect energy security, especially affordability and accessibility dimensions of energy security. Accordingly, while fossil fuels constitute a large part of energy consumption, Russia, Iran, and Azerbaijan have a much place in energy import. In this context, dependence on Russia in energy needs to be re-examined with the recent Russia-Ukraine War by considering Russia's use of energy trump card against EU countries. Moreover, the negative effects of the increase in global energy prices after the start of the war on the affordability dimension of energy security and its reflections on the Turkish economy demonstrate the importance of the affordability dimension for the Turkish economy. Furthermore, the realization of energy imports in foreign currency directly negatively affects affordable access to energy and the current foreign exchange reserves, as in the last currency crisis in Turkey. In this respect, foreign dependence on energy is quite a big risk in terms of both revealing the risk of access to energy in the deterioration of bilateral relations with countries that have a significant share in energy imports and cause to adversely affected by increases in energy price and exchange rate.

The elimination of foreign dependence on energy is possible by either discovering new fossil energy sources within borders or by substituting instead of fossil fuels with alternative energy sources, such as renewable energy sources and nuclear energy. In this context, it can be argued that Turkey's future in energy security lies in renewable energy resources. It should be particularly noted that renewable energy has become more attractive in recent years since unit costs in renewable energy production have decreased considerably in recent years and require quite low fixed costs after installation, and it does not harm the environment with zero carbon emissions. In this context, renewable energy has the potential to positively affect all aspects of the 4A of energy security in Turkey, and it is also important for sustainable development and growth. Accordingly, renewable energy in Turkey contributes to the dimension of availability in terms of reducing foreign dependence on energy, to the dimension of affordability in terms of protecting it from the negative effects of increases in energy prices and exchange rates, to the dimension of accessibility in terms of protecting it against the negativities of energy cuts caused by problems in energy importing countries and transition countries, and to the dimension of acceptability in terms of being eco-friendly contrary to the polluting effects of fossil fuels. In this direction, the attractiveness of renewable energy investments can be increased by giving significant incentives and some special privileges. Moreover, renewable energy investments may be also performed directly by the government.

With this, one of the most striking factors for Turkey in the context of energy security is that Turkey is in a strategic position with a high potential to be an energy corridor both regionally and globally. If Turkey can effectively use this strategic position, it can minimize the negative impacts of both energy import dependence and fluctuations in energy prices arising from this dependence. Thus, significant support can be provided to two of the policies expressed in three main axes for Turkey's energy security, including dependence on energy imports arising from inadequate in terms of energy resources, risks arising from energy price fluctuations in connection with the dependence on energy imports, and environmental risks arising from the low share of renewable energy consumption in total energy consumption. However, Turkey's becoming a major energy corridor is not what will be accomplished in a short time. For this, strategic steps should be taken by carefully analyzing the international balances. In this sense, it can be argued that while the increase in energy prices after the Russia-Ukraine War damages the affordability dimension of energy security in both Turkey and globally, on the other hand, this war may create considerable opportunities for Turkey. In this direction, when looking at alternative regions to Russia, especially for EU countries, Turkey is at a key point in accessing the energy resources of both the Turkic World countries and the Middle East countries. In this direction, international support, including oil and natural gas exploration activities in the Eastern Mediterranean, can be provided by well using the current conjuncture, and significant energy investments can be accomplished. Thus, Turkey can both ensure its own energy security and become a major global actor in energy. Furthermore, strong historical and cultural ties with the countries of the Turkic World have the potential to significantly support policies to be formed based on energy under common interests. The cooperation to be formed in this direction by bringing together the geopolitical position of Turkey and the energy resources of the Turkic World can reflect positively on the energy security of all stakeholders. In this context, the Organization of Turkic States can play a more considerable role in the realization of important projects in the energy context by also taking advantage of the current conjuncture. Thus, the possibility of the emergence of potential energy security risks can be reduced, and the negative impact on economic growth can be prevented by keeping the energy security risk level at reasonable levels. At the same time, a positive effect on economic growth can be achieved by reducing the energy security risk level, as supported by the empirical results. Finally, the energy-saving and energy efficiency policies in energy security are quite important, especially in countries dependent on imports in energy such as Turkey. Creating national awareness in this direction by looking at energy security from the perspective of national security may significantly support uninterrupted access to affordable energy as compatible with its environmental effects. In this direction, a series of suggestions can be made such as giving practices starting from primary schools for the most optimal use of energy resources, promoting public transportation, widespread use of electric cars, and even encouraging the use of energy-saving LED light bulbs, etc.

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