*Gökhan Kartal*
*Niğde Ömer Halisdemir University*
*51240 Niğde, Türkiye*
*gokhankartal.gk@gmail.com*

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# THE RELATIONSHIP BETWEEN ENERGY SECURITY AND MILITARY EXPENDITURES: A BOOTSTRAP PANEL GRANGER CAUSALITY ANALYSIS FOR ENERGY EXPORTER COUNTRIES

## Abstract

**Purpose:** The aim of this study is to analyze the causality relationship between military expenditures and energy security risk levels. In this context, the main purpose of the study is to investigate whether military expenditures have a role in ensuring energy security and to perform a pioneering study examining the relationship between energy security and military expenditures. In addition, the variables of economic growth and energy export revenues are also included in empirical analysis.

**Methodology:** The Kónya (2006) bootstrap panel Granger causality approach is used in empirical analysis. The analysis covers 16 major energy exporter countries and the years 1990 and 2018.

**Results:** It was found that there is one-directional causality from military expenditures to energy security risk levels for three countries, and from energy security risk levels to military expenditures for two countries. On the other hand, it was determined that there is one-directional causality from energy security risk levels to economic growth for four countries, from economic growth to energy security risk levels for two countries, from energy security risk level to energy export revenues for four countries, and from energy export revenues to energy security risk levels for one country. Moreover, it was determined that there is bidirectional causality between energy security risk levels and economic growth for four countries, and between energy security risk levels and energy export revenues for two countries.

**Conclusion:** The results obtained in this study demonstrate that the causality relationship between energy security and other variables (military expenditures, GDP, and energy export income) cannot be generalized across countries. However, it may be argued that energy security is an important policy tool that has important economic consequences for energy-exporting countries through its effects on different variables.

**Keywords:** Energy security, military expenditures, economic growth, energy export revenues, bootstrap panel Granger causality

## 1. Introduction

According to SIPRI (2021), global military expenditures are approximately $1.8 trillion[1] as of 2018. The majority of the global military expenditures have been carried out by the USA with approximately 682.5 billion dollars. The share of the USA in total military expenditure alone is 37.7%, and it is followed by China with 14% and Saudi Arabia with 4.01%. The total share of the top 10 countries in global military expenditures is 76%. Globally, military expenditures increased by approximately 1.94 times compared to 1990. In this period, the military expenditures of the USA increased approximately two times, whereas the military expenditures of China increased approximately 25 times. Accordingly, there is a globally unbalanced distribution of military expenditures.

It is quite remarkable that China's share in global military expenditures was approximately 1% in 1990, while it increased to 14% in 2018. A huge increase in military expenditures in parallel with China's enormous economic growth can be argued as proof that economic growth in China has increased military expenditures. Threats from other global powers that are dissatisfied with China becoming a global power (in a sense, an increase in enemies due to global competition) may have triggered military expenditures by increasing national security risks for China. As a third option, China's desire to have access to global resources as it needs more resources for sustained economic growth as well as to expand to influence the world as a global power in the military sense may have prompted military expenditures. Accordingly, it can be suggested that all these options are partially valid for China.

The main reason for military expenditures is to secure the fundamental rights and freedoms of citizens living within the borders of the country, especially security of life and property. At the same time, as in the case of China, there are many different reasons why countries increase their military expenditures. In this regard, the reasons for increasing military expenditures are e.g. population growth, expanding borders, the possibility of allocating a larger budget to military expenditures thanks to economic growth, increased security risks to natural resources in natural resource-rich countries, increasing global and regional security risks, global power competition, and providing access to global resources to ensure the continuity of economic growth. On the other hand, military expenditures may affect economic growth in two ways. Firstly, in a broadly Keynesian framework, it may stimulate the growth process through increased use of capital stock. In this way, employment, profits, and investment may be stimulated. Secondly, military expenditures may harm economic growth by crowding out investment as well as civilian budget expenditures including health and infrastructure expenditures (Topcu & Aras, 2015, p. 233)

Revenues from energy exports have a large share in the economies of energy exporter countries. In this respect, when analyzing Table 1 for the 16 major energy exporter countries, it is shown that the share of energy export revenues in GDP is above 10% in 10 of these countries. In addition, the panel average is 11.4%. Taking into account the share of export revenues from energy exports in total exports, it is shown that the share of energy exports in total exports is over 10% in all countries - in fact, this rate is over 80% in some countries. Moreover, the panel average is 37.46%. In these countries, it can be expected that fluctuations in energy revenues affect many economic variables, especially export revenues and GDP. Therefore, if diversity of export products cannot be achieved in these countries, it is necessary to ensure the continuity of revenues from energy exports.

At this point, the issue of energy security gains importance. According to the International Energy Agency (IEA) (2020), energy security is "the uninterrupted availability of energy sources at an affordable price". However, energy security is expressed with the 4As of energy security, i.e., availability, affordability, accessibility, and acceptability (Kartal, 2022b, pp. 224-225). In this direction, the IEA definition of energy security can be expanded as "the uninterrupted availability of energy sources that are acceptable with their environmental effects at an affordable price". Here, the most important element of energy security for energy exporter countries is the security of energy resources and export routes. Moreover, having rich energy resources is a source of global power, and on the other hand, it is also a source of conflict in international competition. For this reason, it may be argued that it is necessary to increase military expenditures both to ensure energy security and to deter countries that have ambitions in relation to their resources.

1 For 2020, this figure is approximately 2 trillion dollars.

In addition, it can be expected that an increase in energy export revenues maybe allows more resources to be allocated to military expenditures by increasing the state budget revenue. Moreover, given that military expenditures can also provide safer opportunities for energy export (i.e., increase the level of energy security), it can also be argued that increased military expenditures may contribute to export revenues and thus to the economic growth process. In this direction, this study focuses on the causality relationship among military expenditures and economic growth, energy export revenues, and energy security risk level for 16 important energy exporter countries.

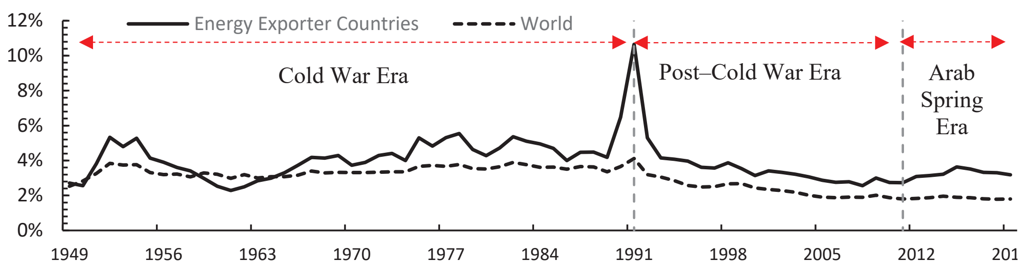
*Table 1 Share of energy exports in GDP and total exports in energy exporter countries*

| C.N | Country | Energy Exports (%GDP) | | | | Energy Exports (%Exports) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1990 | Rank | 2018 | Rank | 1990 | Rank | 2018 | Rank |
| 1 | Algeria | 16.84 | 6 | 23.11 | 4 | 71.83 | 6 | 89.60 | 2 |
| 2 | Australia | 2.40 | 14 | 4.07 | 15 | 15.88 | 14 | 18.65 | 13 |
| 3 | Bahrain | 72.29 | 1 | 18.39 | 5 | 62.56 | 7 | 23.11 | 11 |
| 4 | Canada | 2.14 | 15 | 5.81 | 13 | 8.49 | 15 | 18.11 | 14 |
| 5 | Colombia | 4.19 | 13 | 7.26 | 12 | 22.22 | 12 | 45.69 | 8 |
| 6 | Ecuador | 9.71 | 12 | 8.19 | 11 | 42.65 | 9 | 36.22 | 10 |
| 7 | Indonesia | 10.59 | 10 | 4.03 | 16 | 38.78 | 10 | 19.22 | 12 |
| 8 | Iran | 11.71 | 9 | 14.62 | 9 | 88.19 | 3 | 43.99 | 9 |
| 9 | Kuwait | 42.72 | 3 | 46.49 | 1 | 95.07 | 1 | 81.97 | 4 |
| 10 | Malaysia | 12.26 | 8 | 10.74 | 10 | 16.46 | 13 | 15.66 | 15 |
| 11 | Nigeria | 15.96 | 7 | 14.79 | 8 | 76.10 | 4 | 95.41 | 1 |
| 12 | Norway | 10.05 | 11 | 17.61 | 6 | 25.49 | 11 | 45.80 | 7 |
| 13 | Oman | 43.28 | 2 | 36.30 | 2 | 91.63 | 2 | 62.52 | 6 |
| 14 | Paraguay | 0.01 | 16 | 5.22 | 14 | 0.03 | 16 | 14.54 | 16 |
| 15 | S. Arabia | 29.11 | 4 | 29.44 | 3 | 72.17 | 5 | 73.54 | 5 |
| 16 | Venezuela | 20.19 | 5 | 17.34 | 7 | 52.89 | 8 | 86.79 | 3 |
| | **Panel Average** | **8.67** | - | **11.41** | - | **32.59** | - | **37.46** | - |

*Source: World Bank (2021); UN (2021a); Trademap (2021); Enerdata (2021)*

The change in the share of military expenditures in GDP over time in the 16 major energy exporter countries and worldwide is shown in Figure 1. Accordingly, it is clearly seen that the share of military expenditures in GDP in energy-exporting countries is generally above the world average, except for a few years. This situation suggests that the need for military expenditures is relatively higher in energy exporter countries.

*Figure 1 Share of military expenditures in GDP*




Note: While calculating the averages, the countries with data for the relevant period were considered.
*Source: SIPRI (2021)*

Some statistical data regarding the energy exporter countries included in this study are given in Table 2. According to the information obtained from the table, it can be seen that, compared to 1990, military expenditures increased in all countries except for Iran, Kuwait, and Venezuela. It can be seen that military expenditures in these countries increased approximately 12.6 times in Ecuador, 11.4 times in Colombia, and 10.6 times in Algeria. Moreover, while the total military expenditures of energy exporter countries increased approximately 2.7 times, total global military expenditures increased 1.9 times in this period.

***Table 2 Military expenditures in energy-exporting countries***

| C.N | Country | Military Expenditure | | | Military | | Military | | Energy Security Risk Levels | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1990 | 2018 | Change* | 1990 | 2018 | 1990 | 2018 | 1990 | 2018 | %Change |
| 1 | Algeria | 904 | 9,584 | 10.6 | 1.46 | 5.46 | 8.65 | 23.65 | 891.03 | 1,251.19 | 40.42 |
| 2 | Australia | 6,704 | 26,840 | 4.0 | 2.16 | 1.87 | 89.71 | 46.03 | 716.70 | 805.29 | 12.36 |
| 3 | Bahrain | 239 | 1,528 | 6.4 | 5.66 | 4.06 | 7.83 | 22.06 | 1,527.68 | 1,342.78 | -12.10 |
| 4 | Canada | 11,415 | 22,729 | 2.0 | 1.92 | 1.32 | 89.94 | 22.80 | 754.16 | 801.96 | 6.34 |
| 5 | Colombia | 890 | 10,135 | 11.4 | 1.86 | 3.04 | 44.38 | 41.84 | 768.59 | 677.66 | -11.83 |
| 6 | Ecuador | 202 | 2,549 | 12.6 | 1.33 | 2.37 | 13.65 | 28.95 | 887.63 | 1,042.01 | 17.39 |
| 7 | Indonesia | 1,614 | 7,557 | 4.7 | 1.52 | 0.73 | 14.36 | 17.99 | 897.04 | 931.91 | 3.89 |
| 8 | Iran | 16,474 | 11,231 | -0.3 | 13.20 | 2.47 | 112.71 | 16.92 | 959.68 | 1,370.70 | 42.83 |
| 9 | Kuwait | 8,962 | 7,296 | -0.2 | 48.63 | 5.19 | 113.82 | 11.16 | 1,108.99 | 1,645.39 | 48.37 |
| 10 | Malaysia | 1,125 | 3,470 | 3.1 | 2.56 | 0.97 | 20.84 | 9.01 | 1,006.85 | 1,272.24 | 26.36 |
| 11 | Nigeria | 277 | 2,043 | 7.4 | 0.51 | 0.51 | 3.21 | 3.48 | 818.46 | 837.07 | 2.27 |
| 12 | Norway | 3,395 | 7,067 | 2.1 | 2.83 | 1.63 | 28.21 | 9.25 | 746.17 | 869.35 | 16.51 |
| 13 | Oman | 1,448 | 7,565 | 5.2 | 12.39 | 9.48 | 28.63 | 26.12 | 908.14 | 1,730.74 | 90.58 |
| 14 | Paraguay | 112 | 387 | 3.4 | 1.93 | 0.96 | 13,560 | 18.33 | 1,007.66 | 1,094.04 | 8.57 |
| 15 | S. Arabia | 16,355 | 74,400 | 4.5 | 13.90 | 9.46 | 47.77 | 32.13 | 1,213.73 | 1,517.71 | 25.04 |
| 16 | Venezuela | 738 | 473 | -0.4 | 1.52 | 0.25 | 7.52 | 1.44 | 937.51 | 649.97 | -30.67 |
| **Panel** | | **72,845** | **196,871** | **2.7** | **4.32** | **2.55** | **49.21** | **22.29** | **946.88** | **1,115.00** | **17.76** |
| **World** | | **930,659** | **1,809,337** | **1.9** | **3.66** | **1.79** | **-** | **-** | **1,048.66** | **1,192.84** | **13.75** |

Note: * The relevant value demonstrates how many times it increased in 2018 compared to 1990.
*Source: SIPRI (2021); World Bank (2021); UN (2021a); Trademap (2021); Enerdata (2021); Global Energy Institute (2020)*

According to remarkable results obtained from Table 2, the share of military expenditures in GDP decreased in other countries except for Algeria, Colombia, Ecuador, and Nigeria. Likewise, the share of military expenditures in energy export revenues decreased in other countries, excluding Algeria, Bahrain, Ecuador, and Nigeria. While military expenditures increase in almost all countries, a decrease in the share of military expenditures in GDP can be attributed to high economic growth rates in countries relative to military expenditures in this process. This situation is in line with the global trend, which has fallen from 3.66% to 1.79%. Similarly, in 2018, military expenditures in China increased 25 times compared to 1990, while the share of military expenditures in GDP decreased from 2.5% to 1.9%. Considering the example of China, it may be argued that the main reason for a decrease in the share of military expenditures in GDP in energy exporter countries is also high growth in these countries. When the period between 1990 and 2018 is compared in terms of energy security risk levels, it can be seen that energy security risk level has increased in other countries except for Venezuela, Colombia, and Bahrain.

The next section of this study gives a literature review of the subject. Section 3 introduces empirical methodology used in the study. Finally, the results obtained by empirical analysis are reported in the last section.

## 2. Literature review

There are many studies examining the effect of economic growth on military expenditures using different methods and data from different countries and periods. One of the studies examining this relationship is Benoit's study (1978), which spanned the period from 1955 to 1965 and analyzed 44 less developed countries. The study discovered a strong positive correlation between high defensive loads and rapid economic growth rates in these nations. Chowdhury (1991) investigated a diversified period for each country and found evidence of a causality relationship between defense expenditures and economic growth in 15 developing countries. Moreover, the study identified causality from economic growth to defense expenditures in 7 developing countries and a bidirectional relationship in 3 developing countries. Dritsakis (2004) examined the period from 1960 to 2001 and concluded that there is no cointegrated relationship between defense expenditures and economic growth. However, the Granger causality results highlighted a one-way causality link from economic growth to defense expenditures for both Greece and Türkiye.

Karagianni and Pempetzoglu (2009) focused on Türkiye in the period from 1949 to 2004. The study demonstrated the presence of causality between military expenditures and economic development. Furthermore, it identified both linear and non-linear causal relationships in the context of Türkiye. Hirnissa et al. (2009) conducted a comprehensive study spanning the years 1965 to 2006 across several Southeast Asian nations. For Indonesia, Thailand, and Singapore, the study revealed a long-term relationship between military spending and economic growth. The results were mixed for other nations in the ASEAN-5 group: Singapore exhibited bi-directional causality, Indonesia and Thailand displayed one-way causality from military spending to economic growth, while no significant relationship was observed for Malaysia and the Philippines. Topcu and Aras (2015) examined the period from 1973 to 2010 and explored the interactions between defense expenditures and economic growth in the context of European Union (EU) member states. Their findings reveal a significant long-term relationship within 10 out of 16 EU member states. Notably, Belgium, Italy, Spain, and the UK displayed a bidirectional relationship between defense expenditures and economic growth. Conversely, France, Germany, the Netherlands, and Sweden exhibited one-directional causality from defense expenditures to economic growth. Similarly, Austria, Bulgaria, Hungary, Ireland, Poland, Portugal, Denmark, and Greece displayed one-directional causality from economic growth to defense expenditures. Khalid and Razaq (2015) explored a reverse direction relationship between military spending and economic growth within the United States during the period from 1970 to 2011. The results of their study underscore a reverse direction relationship between military spending and economic growth for the USA. Malizard (2016) focused on the years 1960 to 2011 and found that public expenditures have detrimental effects on economic growth. In contrast, military expenditures were observed to be less harmful compared to non-military civilian expenditures within the European Union (EU15) economies. Augier et al. (2017) evaluated models with the Feder-Ram model and the augmented Solow model to understand economic growth in China. Their findings suggest that the Feder-Ram model poorly explained economic growth in China, while the augmented Solow model demonstrated that a 1% increase in defense expenditures increases economic growth by about 0.15% to 0.19%. Hatemi-J et al. (2018) explored the hypotheses centered around military spending and economic growth. They confirmed the hypothesis linking military spending to economic growth in China and Japan. Moreover, they validated the growth-based hypothesis in several countries, including France, Russia, Saudi Arabia, and the US. The authors revealed that robust economic growth does not inherently lead to automatic growth in military spending, except in the case of Saudi Arabia. Additionally, they postulated that heightened perceptions of threats in these countries correlate with increased defense spending. Bellos (2019) conducted an examination covering the years from 1985 to 2018, focusing on the association between variables in a sample of 31 transition economies. The study unveiled diverse patterns of association, with certain samples indicating positive relationships, while others displayed negative associations. Importantly, the direction of causality is from military expenditure towards growth and development-related variables in the vast majority of the cases.

Chun (2010) conducted a study spanning the period from 1997 to 2007, focusing on five oil-rich countries. The study uncovers an inelastic correlation between oil revenues and defense expenditures in these nations. Notably, during periods characterized by substantial declines in oil revenues, governments displayed a propensity to either augment their defense expenditures or, at the very least, mitigate a decrease in defense spending at a slower pace compared to a decline in oil revenues. Likewise, at a time of high oil revenues, defense expenditures often witnessed a more pronounced increase compared to an upsurge in oil sales. The author posits that in both scenarios, governments seemed to safeguard defense expenditures in the face of adverse economic circumstances. Farzanegan (2011) explored the years 1959 to 2007 and focused on Iran's reactions to shocks in oil revenues or oil prices. The study found that while Iran's military and security spending exhibited noteworthy responses to these shocks, its social spending components displayed relatively muted reactions. Perlo-Freeman (2012) analyzed the period from 1975 to 2008, focusing specifically on Algerian military spending. The study unearthed a statistically significant and positive effect of oil income on Algerian military expenditures, underscoring the influence of oil revenues on defense spending. Cotet and Tsui (2013) undertook a comprehensive examination spanning the period from 1930 to 2003, but focusing especially on the period from 1988 to 2003. The study elucidated a meaningful positive correlation between oil assets and the defense burden in non-democratic countries. This connection sheds light on the role of oil assets in shaping defense expenditure patterns within such political contexts. Ali and Abdellatif (2015) conducted an investigation spanning from 1987 to 2012, focusing on the Middle East and North Africa (MENA) countries. The study reveals that certain natural resources, notably oil and forest resources, have led to the escalation of military expenditures in these regions. Additionally, the study found that the rent received from coal and natural gas exerts a negative influence on military expenditures, while the rent derived from minerals has no discernible impact on military spending. These findings were established while accounting for variables such as GDP growth and per capita income. Al-Mawali (2015) explored the years 1987 to 2012, particularly concentrating on the Gulf Cooperation Council (GCC) countries. The study suggests that military spending is predominantly driven by the rent obtained from oil rather than gas and minerals. Furthermore, the study concludes that the Gulf Wars (I and II) and the Arab Spring events do not hold statistical significance in explaining the variance in GCC's military expenditures. Khan and Haque (2019) undertook a comprehensive analysis from 1986 to 2016, encompassing the Middle East region. The study uncovers a significant adverse correlation between military expenditures and both exports and oil rents. This correlation persists across the analysis of countries with higher average oil exports than the Middle East norm. Moreover, the study reveals that the military burden exerts a negative influence on economic growth throughout the entire model specification. Notably, the authors observe that a decrease in military spending over time indicates adverse causality between development and conflict. Erdoğan et al. (2020) conducted a study with varying periods across different countries. Their research established a connection between variables encompassing entire countries. Furthermore, the study found that volatility in oil prices positively impacts military spending in six Gulf Cooperation Council (GCC) countries, with the exception of Bahrain. Bakirtas (2020) focused on the years 1980 to 2016, particularly concentrating on seven countries within the Organization of the Petroleum Exporting Countries (OPEC). The study discerns causality in several directions: from crude oil exports and crude oil prices to military spending, from crude oil exports and military spending to crude oil prices, and from spending and crude oil prices to crude oil exports. These intricate relationships highlight the influence of oil markets on military expenditures. Dizaji and Farzanegan (2021) analyzed the period from 1960 to 2017, with a specific focus on Iran. The study demonstrates that an increase in the density of sanctions against Iran is associated with a considerable decrease in military expenditures, both in the short term and in the long term. Notably, multilateral sanctions exhibit a particularly pronounced impact, leading to a decline of approximately 77% in Iran's military expenditures in the long term.

Accordingly, when the literature examining the effect of economic growth on military expenditures is generally evaluated, it is seen that there is no certain consensus in the literature. In this direction, there are different results in different countries and time periods. However, the dominant view is that there is a positive relationship between economic growth and military expenditures. Likewise, there is no consensus on the impact of energy export revenues and resource wealth on military spending. Again, the dominant view here is that there is a positive relationship between energy export revenues on military expenditures.

On the other hand, there are few studies that analyze the effects of energy security on economic growth. In a series of research endeavors, various scholars have examined the intricate relationship between energy security and economic growth across different periods and regions. Kartal (2018) and Kartal and Öztürk (2020) investigated the interplay between these variables within the time frame spanning the period from 1996 to 2014 for 15 Middle Eastern countries. Their study revealed a notable long-term connection between energy security risk levels and economic growth. Specifically, they found that an escalation in energy security risk levels exerted a negative influence on long-term economic growth. However, the cross-sectional dependence was not considered in the study. Additionally, their analysis presented evidence supporting a bidirectional causal relationship between energy security and economic growth. Kartal (2022d) conducted an analysis of the intricate relationship between energy security, economic growth, and exports within the context of 16 Middle Eastern countries. The study covered the period from 1980 to 2016, and special attention was paid to addressing cross-sectional dependence. The findings of this study unveiled a noteworthy pattern: a 1% escalation in energy security risk level corresponded to an approximate 0.66% reduction in economic growth. Furthermore, it is detected that a bidirectional causality relationship existed between energy security, economic growth, and exports. Stavytskyy et al. (2018) contributed to this discourse by examining 29 European countries in the period from 1997 to 2016. Through their research, they discerned a positive correlation between an increase in gross domestic product (GDP) and the new Energy Security Index (NSI). Conversely, their findings indicated a negative correlation between GDP and the Consumer Price Index (CPI). Fang et al. (2018) took a distinctive approach by proposing five distinct dimensions to characterize energy security: availability, accessibility, affordability, acceptability, and developability. They employed these dimensions to establish China's Sustainable Energy Security (CSES) evaluation index model. This study, conducted between 2005 and 2015, offered insights into China's energy security dynamics and revealed changing trends within the proposed model. Their results spotlighted the pivotal importance of availability and developability within China's energy security index system. The authors identified a downward trajectory for availability and an inverted U-shaped trend for developability, with the nadir in 2011. Notably, the years 2008 to 2012 were identified as a period of risk for China's sustainable energy security. Le and Nguyen (2019) extended the analysis to a global scale, encompassing 74 countries from 2002 to 2013. They demonstrated a positive relationship between energy security and economic growth for both the entire sample and sub-samples. Their findings also indicated that energy insecurity, quantified by energy density and carbon density, had a negative impact on economic growth. The authors underscored the interconnectedness of economic development, energy security, and climate change mitigation at a global level, advocating for comprehensive policies to address these interlinked challenges. Shifting focus to the Turkic world countries including Türkiye, Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan, Kartal (2022a) evaluated the relationship between energy security and economic growth from 1992 to 2016. Employing the panel Durbin-Hausman cointegration test, the study established a significant long-term association between the variables. Notably, a 1% increase in energy security risk level within the Turkic world countries was found to correspond to a reduction of approximately 0.95% in economic growth. In further investigations, Kartal (2022b) utilized asymmetric causality analysis for the period from 1980 to 2018. The findings indicated unidirectional causality, where an increase in energy security risk level led to negative shocks in GDP. Expanding on this topic, Kartal (2022c) employed the NARDL and ARDL methods to probe the asymmetric effects of energy security on Turkish economic growth during the same period. The study identified an asymmetrical relationship between energy security and economic growth in Türkiye. The results showcased that a 1% escalation in energy security risk level correlated with an approximate 0.60% reduction in economic growth, whereas a 1% decrease in energy security risk level corresponded roughly with a 1.72% upswing in economic growth. Lastly, Kartal (2022e) examined a broad range of 74 countries, revealing varying causality relationships between energy security risk level and GDP. While unidirectional causality from energy security risk level to GDP was established for 14 countries and from GDP to energy security risk level for 20 countries, a bidirectional causal association emerged for 22 countries. Notably, 18 countries exhibited no discernible causality between energy security risk level and GDP.

These cumulative research endeavors shed light on the intricate interdependencies between energy security and economic growth across diverse temporal and geographical contexts. Despite that, according to the literature review conducted in this study, although there are many studies examining the effect of economic growth and energy exports on military expenditures and between energy security and economic growth, empirical studies examining the relationship between energy security and military expenditures cannot be determined. In this context, this paper investigating the causality relationship between economic growth, energy export revenues, and military expenditures, as well as the causality relationship between energy security and military expenditures, was designed to fill this important gap in the literature.

## 3. Data and methodology

This study aims to examine the causality relationship between military expenditures and economic growth, energy export revenues, and energy security risk level for 16 major energy exporter countries between 1990 and 2018 by using Kónya's (2006) bootstrap panel causality approach.[2] The variables included in the empirical analysis and the sources the variables were obtained from are given in Table 3.the variables were obtained from are given in Table 3.

2 Econometric analysis was carried out by using Gauss21 econometrics package program and Nazlıoğlu's (2021) Gauss library.

***Table 3 Definitions and data sources***

| Data | Definitions | Main source | Additional source(s) |
|---|---|---|---|
| me | Military expenditure (current USD) | SIPRI (2021) | World Bank (2021); Global Firepower (2021) |
| enx | Energy export revenues (current USD) (HS Code: 27) | UN (2021a) | Trademap (2021); Enerdata (2021) |
| gdp | Gross domestic product | World Bank (2021) | IMF (International Monetary Fund (IMF), 2021); UN (2021b); UN (2021c) |
| es | Energy security risk index | Global Energy Institute (2020) | |

Note: Missing data in the "main source" were supplemented with the help of "additional sources".

*Source: Author*

The biggest advantage of Kónya's (2006) bootstrap panel causality, which is based on the seemingly unrelated regression (SUR) method and assumed country-specific heterogeneity, does not require any pre-testing such as unit roots and cointegration and takes into account cross-sectional dependence. Kónya's (2006) bootstrap panel causality, which was generated to analyze the causality relationship between military expenditures and economic growth, energy export revenues and energy security risk level in this study, is based on the following systems of equations:

$$\begin{aligned} me_{1,t} &= \alpha_{1,1} + \sum_{i=1}^{kme} \beta_{1,1,i} me_{1,t-i} + \sum_{i=1}^{kenx} \delta_{1,1,i} ex_{1,t-i} + \varepsilon_{1,1,t} \\ me_{2,t} &= \alpha_{1,2} + \sum_{i=1}^{kme} \beta_{1,2,i} me_{2,t-i} + \sum_{i=1}^{kenx} \delta_{1,2,i} ex_{2,t-i} + \varepsilon_{1,2,t} \\ &\vdots \\ me_{N,t} &= \alpha_{1,N} + \sum_{i=1}^{kme} \beta_{1,N,i} me_{N,t-i} + \sum_{i=1}^{kenx} \delta_{1,N,i} ex_{N,t-i} + \varepsilon_{1,N,t} \end{aligned} \tag{1}$$

and

$$\begin{aligned} enx_{1,t} &= \alpha_{2,1} + \sum_{i=1}^{kme} \beta_{2,1,i} me_{1,t-i} + \sum_{i=1}^{kenx} \delta_{2,1,i} ex_{1,t-i} + \varepsilon_{2,1,t} \\ enx_{2,t} &= \alpha_{2,2} + \sum_{i=1}^{kme} \beta_{2,2,i} me_{2,t-i} + \sum_{i=1}^{kenx} \delta_{2,2,i} ex_{2,t-i} + \varepsilon_{2,2,t} \\ &\vdots \\ enx_{N,t} &= \alpha_{2,N} + \sum_{i=1}^{kme} \beta_{2,N,i} me_{N,t-i} + \sum_{i=1}^{kenx} \delta_{2,N,i} ex_{N,t-i} + \varepsilon_{2,N,t} \end{aligned} \tag{2}$$

and

$$\begin{aligned} me_{1,t} &= \alpha_{1,1} + \sum_{i=1}^{kme} \beta_{1,1,i} me_{1,t-i} + \sum_{i=1}^{kgdp} \delta_{1,1,i} gdp_{1,t-i} + \varepsilon_{1,1,t} \\ me_{2,t} &= \alpha_{1,2} + \sum_{i=1}^{kme} \beta_{1,2,i} me_{2,t-i} + \sum_{i=1}^{kgdp} \delta_{1,2,i} gdp_{2,t-i} + \varepsilon_{1,2,t} \\ &\vdots \\ me_{N,t} &= \alpha_{1,N} + \sum_{i=1}^{kme} \beta_{1,N,i} me_{N,t-i} + \sum_{i=1}^{kgdp} \delta_{1,N,i} gdp_{N,t-i} + \varepsilon_{1,N,t} \end{aligned} \tag{3}$$

and

$$\begin{aligned} \mathrm{gdp}_{1,t} &= \alpha_{2,1} + \sum_{i=1}^{kme} \beta_{2,1,i} \mathrm{me}_{1,t-i} + \sum_{i=1}^{kgdp} \delta_{2,1,i} \mathrm{gdp}_{1,t-i} + \varepsilon_{2,1,t} \\ \mathrm{gdp}_{2,t} &= \alpha_{2,2} + \sum_{i=1}^{kme} \beta_{2,2,i} \mathrm{me}_{2,t-i} + \sum_{i=1}^{kgdp} \delta_{2,2,i} \mathrm{gdp}_{2,t-i} + \varepsilon_{2,2,t} \\ &\vdots \\ \mathrm{gdp}_{N,t} &= \alpha_{2,N} + \sum_{i=1}^{kme} \beta_{2,N,i} \mathrm{me}_{N,t-i} + \sum_{i=1}^{kgdp} \delta_{2,N,i} \mathrm{gdp}_{N,t-i} + \varepsilon_{2,N,t} \end{aligned} \tag{4}$$

and

$$\begin{aligned} me_{1,t} &= \alpha_{1,1} + \sum_{i=1}^{kme} \beta_{1,1,i} me_{1,t-i} + \sum_{i=1}^{kes} \delta_{1,1,i} es_{1,t-i} + \varepsilon_{1,1,t} \\ me_{2,t} &= \alpha_{1,2} + \sum_{i=1}^{kme} \beta_{1,2,i} me_{2,t-i} + \sum_{i=1}^{kes} \delta_{1,2,i} es_{2,t-i} + \varepsilon_{1,2,t} \\ &\vdots \\ me_{N,t} &= \alpha_{1,N} + \sum_{i=1}^{kme} \beta_{1,N,i} me_{N,t-i} + \sum_{i=1}^{kes} \delta_{1,N,i} es_{N,t-i} + \varepsilon_{1,N,t} \end{aligned} \tag{5}$$

and

$$\begin{aligned} es_{1,t} &= \alpha_{2,1} + \sum_{i=1}^{kme} \beta_{2,1,i} me_{1,t-i} + \sum_{i=1}^{kes} \delta_{2,1,i} es_{1,t-i} + \varepsilon_{2,1,t} \\ es_{2,t} &= \alpha_{2,2} + \sum_{i=1}^{kme} \beta_{2,2,i} me_{2,t-i} + \sum_{i=1}^{kes} \delta_{2,2,i} es_{2,t-i} + \varepsilon_{2,2,t} \\ &\vdots \\ es_{N,t} &= \alpha_{2,N} + \sum_{i=1}^{kme} \beta_{2,N,i} me_{N,t-i} + \sum_{i=1}^{kes} \delta_{2,N,i} es_{N,t-i} + \varepsilon_{2,N,t} \end{aligned} \tag{6}$$

The following notations are used in the systems of equations given above: "me"- military expenditure, "enx" - energy export revenues, "gdp" - gross domestic product, "es" - energy security risk level, "N" - number of countries, "T" - time period, and "k" - lag length. Accordingly, there is causality from export revenues to military expenditure in Eq. (1), from military expenditure to energy export revenues in Eq. (2), from gross domestic product to military expenditure in Eq. (3), from military expenditure to gross domestic product in Eq. (4), from energy security to military expenditure in Eq. (5), and from military expenditure to energy security in Eq. (6).

In this study, the slope homogeneity test, which is one of the two pre-testings required for Kónya's (2006) bootstrap panel causality approach, was carried out with the delta tests proposed by Pesaran and Yamagata (2008), which derived from the $\hat{S}$ test of Swamy (1970). While the null hypothesis of these tests is that parameters are homogeneous, an alternative hypothesis is that parameters are heterogeneous.

Whether the data sets used in this study contain cross-sectional dependence was investigated using by the $LM_{BP}$ test (Breusch & Pagan, 1980), the $CD_{LM}$ test (Pesaran, 2004), the CD test (Pesaran, 2004), and the $LM_{adj}$ test (Pesaran et al., 2008). The null hypothesis of these tests is that there is no cross-sectional dependence, while an alternative hypothesis is that there is cross-sectional dependence.

## 4. Empirical results

Cross-sectional dependence tests and slope heterogeneity tests need to be implemented before analyzing the Kónya (2006) bootstrap panel granger causality. Accordingly, test results, which include delta tests for slope heterogeneity detection and the $LM_{BP}$ (Breusch & Pagan, 1980), the $CD_{LM}$ (Pesaran, 2004), the CD (Pesaran, 2004), and the LMadj (Pesaran et al., 2008) for cross-sectional dependence detection, are given in Table 4. When the results obtained from the cross-sectional dependence tests were examined, the null hypothesis stating that there is no cross-sectional dependence was rejected at a 1% significance level, and the alternative hypothesis stating that there is cross-sectional dependence was accepted, except for the result obtained from the $CD_{LM}$ (2004) test for the lnme variable. Considering the results obtained from the CD (Pesaran, 2004) test for the lnme variable, the null hypothesis was rejected at a 10% significance level. Likewise, when the results obtained from delta tests for slope heterogeneity were examined, the null hypothesis indicating that parameters are homogeneous was rejected at a 1% significance level, and the alternative hypothesis indicating that the parameters are heterogeneous was accepted.

***Table 4 Cross-sectional dependence and slope heterogeneity tests***

| Tests | lnme | | lnenx | | lngdp | | lnes | |
|---|---|---|---|---|---|---|---|---|
| | Stat. | p-val. | Stat. | p-val. | Stat. | p-val. | Stat. | p-val. |
| $LM_{BP}$ | 228.609 | 0.000 | 344.247 | 0.000 | 231.427 | 0.000 | 190.185 | 0.000 |
| $CD_{LM}$ | 7.011 | 0.000 | 14.475 | 0.000 | 7.193 | 0.000 | 4.530 | 0.000 |
| CD | -1.442 | 0.075 | 7.618 | 0.000 | -2.294 | 0.011 | -2.914 | 0.002 |
| $LM_{adj}$ | 20.638 | 0.000 | 0.914 | 0.180 | 6.285 | 0.000 | 3.809 | 0.000 |
| Delta | 3.014 | 0.001 | 2.026 | 0.021 | 4.280 | 0.000 | 2.555 | 0.005 |
| $Delta_{adj}$ | 3.183 | 0.001 | 2.140 | 0.016 | 4.520 | 0.000 | 2.698 | 0.003 |

*Source: Author*

Causality analysis is performed after providing the necessary pre-conditions for the Kónya (2006) bootstrap panel granger causality test. The results obtained from Eq. (1) expressing causality from energy export revenues to military expenditure, and Eq. (2) expressing causality from military expenditure to energy export revenues are shown in Table 5. According to the results obtained, it was determined that there is causality from export revenues to military expenditure for Canada, Iran, Norway, Oman, and Saudi Arabia, and that there is causality from military expenditure to energy export revenues for Algeria, Colombia, and Nigeria.

***Table 5 Panel causality test results (energy export revenues vs. military expenditure)***

| CN | Countries | $H_0$: ENX does not cause ME | | | | $H_0$: ME does not cause ENX | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical values | | | Statistic | Critical values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 12.602 | 75.131 | 53.835 | 46.037 | 6.118** | 9.001 | 5.831 | 4.461 |
| 2 | Australia | 6.968 | 70.554 | 40.710 | 32.267 | 3.506 | 55.525 | 41.031 | 34.573 |
| 3 | Bahrain | 15.855 | 50.933 | 34.308 | 25.656 | 0.768 | 19.777 | 15.695 | 13.440 |
| 4 | Canada | 12.109*** | 11.914 | 8.006 | 6.256 | 0.033 | 65.061 | 45.267 | 37.512 |
| 5 | Colombia | 0.407 | 13.289 | 7.944 | 5.731 | 30.145** | 50.085 | 29.363 | 22.478 |
| 6 | Ecuador | 26.828 | 53.599 | 39.993 | 35.180 | 10.162 | 31.597 | 23.982 | 21.102 |
| 7 | Indonesia | 3.341 | 21.583 | 14.202 | 11.149 | 0.225 | 41.433 | 26.218 | 21.495 |
| 8 | Iran | 9.127* | 17.338 | 9.628 | 6.698 | 0.939 | 39.524 | 21.572 | 12.833 |
| 9 | Kuwait | 13.893 | 129.040 | 95.448 | 78.077 | 2.111 | 76.210 | 60.235 | 49.500 |
| 10 | Malaysia | 27.629 | 68.072 | 44.162 | 33.714 | 12.212 | 67.855 | 41.625 | 32.588 |
| 11 | Nigeria | 6.970 | 45.390 | 30.557 | 24.199 | 3.392** | 5.531 | 3.350 | 2.343 |
| 12 | Norway | 11.497** | 11.795 | 6.719 | 4.960 | 0.710 | 18.054 | 12.131 | 9.946 |
| 13 | Oman | 11.485** | 19.786 | 11.466 | 8.786 | 0.960 | 22.752 | 13.881 | 10.272 |
| 14 | Paraguay | 0.895 | 86.091 | 58.017 | 48.484 | 0.352 | 16.345 | 10.246 | 7.638 |
| 15 | S. Arabia | 36.951*** | 18.741 | 14.053 | 10.824 | 2.117 | 52.752 | 34.835 | 28.454 |
| 16 | Venezuela | 2.931 | 22.004 | 10.015 | 7.271 | 1.846 | 31.160 | 16.035 | 10.381 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*

The results obtained from Eq. (3) expressing causality from GDP to military expenditure and Eq. (4) expressing causality from military expenditure to GDP are shown in Table 6. According to the results obtained, it was determined that there is one-directional causality from GDP to military expenditure for Bahrain, Canada, Colombia, Norway, Oman, and Saudi Arabia, there is one-directional causality from military expenditure to GDP for Australia, Indonesia, Nigeria, Paraguay, and Venezuela, and there is bidirectional causality between military expenditure and GDP for Iran.

***Table 6 Panel causality test results (GDP vs. military expenditure)***

| CN | Countries | $H_0$: GDP does not cause ME | | | | $H_0$: ME does not cause GDP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical values | | | Statistic | Critical values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 6.282 | 20.411 | 15.699 | 12.904 | 3.608 | 9.621 | 7.042 | 5.735 |
| 2 | Australia | 0.042 | 58.531 | 39.808 | 32.305 | 133.259*** | 73.650 | 56.619 | 48.992 |
| 3 | Bahrain | 27.828** | 43.512 | 23.811 | 16.799 | 0.000 | 23.333 | 18.173 | 16.475 |
| 4 | Canada | 17.528** | 18.087 | 10.553 | 7.372 | 9.180 | 61.755 | 41.868 | 35.266 |
| 5 | Colombia | 9.301*** | 6.917 | 4.341 | 3.076 | 0.376 | 47.738 | 29.472 | 23.031 |
| 6 | Ecuador | 6.369 | 52.323 | 31.520 | 25.964 | 0.059 | 30.977 | 23.607 | 20.475 |
| 7 | Indonesia | 12.091 | 23.775 | 15.772 | 12.140 | 37.052*** | 32.597 | 21.421 | 17.285 |
| 8 | Iran | 12.519** | 21.539 | 10.736 | 7.207 | 19.608** | 29.188 | 13.008 | 8.395 |
| 9 | Kuwait | 9.062 | 27.653 | 20.221 | 17.800 | 0.051 | 71.469 | 58.058 | 50.503 |
| 10 | Malaysia | 9.846 | 61.688 | 37.345 | 31.593 | 0.045 | 70.079 | 49.558 | 41.317 |
| 11 | Nigeria | 4.383 | 45.214 | 25.417 | 17.072 | 4.647** | 4.712 | 2.367 | 1.624 |
| 12 | Norway | 7.702* | 18.172 | 10.616 | 7.282 | 3.118 | 17.462 | 11.195 | 9.042 |
| 13 | Oman | 17.898*** | 8.239 | 4.704 | 3.370 | 2.296 | 23.392 | 13.345 | 10.129 |
| 14 | Paraguay | 3.980 | 59.624 | 34.634 | 28.936 | 6.069* | 12.227 | 7.071 | 5.558 |
| 15 | S. Arabia | 83.095*** | 22.897 | 14.870 | 11.689 | 0.837 | 40.067 | 30.361 | 25.972 |
| 16 | Venezuela | 2.576 | 16.924 | 9.334 | 7.009 | 15.889** | 24.047 | 13.656 | 9.981 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*

The results from the Kónya (2006) bootstrap panel causality test obtained from Eq. (5) expressing causality from energy security to military expenditure and Eq. (6) expressing causality from military expenditure to energy security are shown in Table 7. According to the results obtained, it was determined that there is one-directional causality from energy security to military expenditure for Iran and Oman, and there is one-directional causality from military expenditure to energy security for Algeria, Nigeria, and Saudi Arabia.

***Table 7 Panel causality test results (energy security vs. military expenditure)***

| CN | Countries | $H_0$: ES does not cause ME | | | | $H_0$: ME does not cause ES | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical values | | | Statistic | Critical values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 1.705 | 55.079 | 40.639 | 34.719 | 13.262*** | 8.519 | 6.204 | 4.988 |
| 2 | Australia | 18.645 | 54.073 | 34.835 | 28.076 | 1.580 | 45.913 | 36.515 | 31.770 |
| 3 | Bahrain | 0.283 | 84.773 | 55.053 | 44.336 | 2.000 | 23.198 | 16.134 | 13.828 |
| 4 | Canada | 3.006 | 10.478 | 6.973 | 5.785 | 6.680 | 70.674 | 48.674 | 42.057 |
| 5 | Colombia | 0.053 | 9.537 | 6.021 | 4.178 | 0.100 | 22.377 | 15.674 | 11.539 |
| 6 | Ecuador | 5.893 | 47.543 | 28.787 | 22.130 | 9.516 | 39.794 | 25.944 | 22.540 |
| 7 | Indonesia | 1.204 | 6.888 | 4.362 | 3.066 | 1.870 | 34.916 | 25.379 | 19.844 |
| 8 | Iran | 15.383* | 30.255 | 16.693 | 11.189 | 0.946 | 27.789 | 12.188 | 8.123 |
| 9 | Kuwait | 7.827 | 23.524 | 17.524 | 14.542 | 0.644 | 74.674 | 51.662 | 43.511 |
| 10 | Malaysia | 16.629 | 56.873 | 37.676 | 31.601 | 7.786 | 43.234 | 32.436 | 26.934 |
| 11 | Nigeria | 0.051 | 13.371 | 8.497 | 5.835 | 10.183*** | 4.945 | 2.689 | 1.908 |
| 12 | Norway | 0.195 | 36.988 | 25.529 | 20.393 | 0.907 | 22.388 | 16.373 | 14.022 |
| 13 | Oman | 23.164*** | 19.421 | 11.958 | 9.335 | 0.506 | 16.497 | 9.887 | 7.060 |
| 14 | Paraguay | 0.005 | 4.690 | 2.692 | 1.854 | 0.059 | 11.445 | 6.261 | 4.544 |
| 15 | S. Arabia | 0.129 | 15.047 | 8.294 | 5.422 | 40.516** | 45.411 | 32.448 | 27.010 |
| 16 | Venezuela | 5.455 | 23.233 | 12.746 | 8.932 | 0.717 | 28.468 | 15.744 | 10.397 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*

Moreover, all results are summarized in Table 8 and Table 9, including causality from GDP to energy export revenues, from energy export revenues to GDP, from energy security to GDP, and from GDP to energy security (for results, see Appendix 1, Appendix 2, and Appendix 3).

***Table 8 Summary of the direction of causality***

| Causality | dza | aus | bhr | can | col | ecu | idn | irn | kwt | mys | nga | nor | omn | pry | sau | ven |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| enx → me | | | | *** | | | | * | | | | ** | ** | | *** | |
| gdp → me | | | ** | ** | *** | | | ** | | | | * | *** | | *** | |
| es → me | | | | | | | | * | | | | | *** | | | |
| me →enx | ** | | | | ** | | | | | | ** | | | | | |
| gdp → enx | | | | | *** | | | | | | | | *** | | | * |
| es → enx | | | | * | ** | | | | | * | | | ** | *** | | |
| me → gdp | | *** | | | | | *** | ** | | | ** | | | * | | ** |
| enx → gdp | | | | | *** | ** | *** | *** | | * | | | * | | *** | *** |
| es → gdp | | | | | | | | | | | | | | | | |
| me → es | *** | | | | | | | | | | *** | | | | ** | |
| enx → es | | | | ** | | | | ** | | | | | ** | | | |
| gdp → es | | | | *** | | | | *** | ** | | | | *** | | ** | * |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively. "→" represents the direction of causality.

*Source: Author*

When the results obtained for the countries are examined, there are one-directional causality relationships from military expenditures to energy export revenues and energy security in Algeria. There is one-directional causality from military expenditures to GDP in Australia. There is one-directional causality from GDP to military expenditures in Bahrain. There are one-directional causality relationships from energy export revenues and GDP to military expenditures, from GDP to energy security, and there is bidirectional causality between energy security and energy export revenues in Canada. There is one-directional causality from military expenditures to energy export revenues, from GDP to military expenditures and energy export revenues, and from energy security to GDP energy export revenues in Colombia. There is one-directional causality from energy security to GDP in Ecuador. There is one-directional causality from military expenditures and energy security to GDP in Indonesia. For Iran, there is one-directional causality from energy export revenues to military expenditures, GDP, and energy security, and from energy security to military expenditures. There is bidirectional causality between military expenditures and GDP, and energy security and GDP. There is one-directional causality from GDP to energy security in Kuwait. There is one-directional causality from energy security to GDP and energy export revenues in Malaysia. There is one-directional causality from military expenditures to energy export revenues, and GDP and energy security in Nigeria. There is one-directional causality from energy export revenues and GDP to military expenditures in Norway. There is one-directional causality from energy export revenues, GDP, and energy security to military expenditures, and from GDP to energy export revenues, and there is bidirectional causality between GDP and energy security, and energy export revenues and energy security in Oman. There is one-directional causality from military expenditures to GDP, and from energy security to energy export revenues in Paraguay. There is one-directional causality from energy export revenues and GDP to military expenditures, from military expenditures to energy security, and from energy security to energy export revenues. There is bidirectional causality between GDP and energy security in Saudi Arabia. And finally, there is one-directional causality from military expenditures to GDP, and bidirectional causality between GDP and energy export revenues, and GDP and energy security in Venezuela.

***Table 9 Summary of the direction of causality by country***

| CN | Countries | ENX vs ME | GDP vs ME | ES vs ME | GDP vs ENX | GDP vs ES | ES vs ENX |
|---|---|---|---|---|---|---|---|
| 1 | Algeria | ← | - | ← | - | - | - |
| 2 | Australia | - | ← | - | - | - | - |
| 3 | Bahrain | - | → | - | - | - | - |
| 4 | Canada | → | → | - | - | → | ⇄ |
| 5 | Colombia | ← | → | - | → | ← | → |
| 6 | Ecuador | - | - | - | - | ← | - |
| 7 | Indonesia | - | ← | - | - | ← | - |
| 8 | Iran | → | ⇄ | → | ← | ⇄ | ← |
| 9 | Kuwait | - | - | - | - | → | - |
| 10 | Malaysia | - | - | - | - | ← | → |
| 11 | Nigeria | ← | ← | ← | - | - | - |
| 12 | Norway | → | → | - | - | - | - |
| 13 | Oman | → | → | → | → | ⇄ | ⇄ |
| 14 | Paraguay | - | ← | - | - | - | → |
| 15 | Saudi Arabia | → | → | ← | - | ⇄ | → |
| 16 | Venezuela | - | ← | - | ⇄ | ⇄ | - |

Note: "→, ← and ⇄" represent the direction of causality.

*Source: Author*

## *5. Conclusion*

This study aims to examine the causality relationship between military expenditures and economic growth, energy export revenues, and energy security risk level for 16 major energy exporter countries between 1990 and 2018 using the Kónya bootstrap panel causality approach. According to the results obtained, it was found that there is at least one causality relationship between military expenditures, energy export revenues, GDP, and energy security for all countries. Moreover, it was determined that there is at least one causal relationship between military expenditures and other variables, including energy export revenues, GDP, and energy security in all countries except Ecuador, Kuwait, and Malaysia.

When the results obtained are evaluated, the fact that there is causality determined from energy export revenues to military expenditures in Canada, Iran, Norway, Oman, and Saudi Arabia, demonstrates that military expenditures are affected by energy export revenues in these countries. Therefore, it may be argued that energy stimulation of export revenues in these countries may also stimulate military expenditures. On the other hand, the fact that there is causality determined from military expenditures to energy export revenues in Algeria, Colombia, and Nigeria, demonstrates that energy export revenues are affected by military expenditures in these countries.

Moreover, the fact that there is causality determined from GDP to military expenditures in Bahrain, Canada, Colombia, Iran, Norway, Oman, and Saudi Arabia, demonstrates that military expenditures are affected by GDP in these countries. Therefore, it may be argued that stimulation of economic growth in these countries may also stimulate military expenditures. On the other hand, the fact that there is causality determined from military expenditures to GDP in Australia, Indonesia, Iran, Nigeria, Paraguay, and Venezuela, demonstrates that GDP is affected by military expenditures in these countries. Therefore, it may be argued that military expenditures stimulate economic growth in these countries.

When the results obtained for the causal relationship between military expenditures, economic growth, and energy export revenues are evaluated in general, they demonstrate that they cannot be generalized across countries. However, it may be argued that the direction of causality between military expenditures and energy export revenues is predominantly from energy export revenues to military expenditures, while causality between economic growth and military expenditures is predominantly from economic growth to military expenditures.

The most important factor that distinguishes this study from other studies on the subject is also the inclusion of the energy security variable in the analysis. Quite remarkable results have been obtained in this direction. Firstly, the fact that there is causality determined from military expenditures to energy security risk level in Algeria, Nigeria, and Saudi Arabia, demonstrates that energy security risk level is affected by military expenditures in these countries. On the other hand, the fact that there is causality determined from energy security risk level to military expenditures in Iran and Oman, demonstrates that military expenditures are affected by energy security risk level in these countries. Therefore, it may be argued that military expenditures are an important policy tool for ensuring energy security in these countries.

Secondly, the fact that there is causality determined from energy security risk level to economic growth in Colombia, Ecuador, Indonesia, Iran, Kuwait, Oman, and Saudi Arabia, demonstrates that economic growth is affected by energy security risk level in these countries. Therefore, it may be argued that energy security promotes economic growth in these countries, and energy security is an important policy tool for ensuring economic growth. On the other hand, the fact that there is causality determined from economic growth to energy security risk level in Canada, Iran, Kuwait, Oman, Saudi Arabia, and Venezuela, demonstrates that energy security risk level is affected by economic growth in these countries. This result demonstrates that economic growth is an important factor in ensuring energy security in these countries. It is also quite remarkable that there is a bidirectional causality relationship between energy security and GDP in Iran, Saudi Arabia, and Venezuela, which are among the world's most important energy exporters.

Thirdly, the fact that there is causality determined from energy security risk level to energy export revenues in Canada, Colombia, Malaysia, Oman, Paraguay, and Saudi Arabia, demonstrates that energy export revenues are affected by energy security risk level in these countries. Therefore, it may be argued that among the policies to be implemented to increase energy export revenues, policies for energy security should also be included in these countries. On the other hand, the fact that there is causality determined from energy export revenues to energy security risk level in Canada, Iran, and Oman, demonstrates that energy security risk level is affected by energy export revenues in these countries. Since fluctuations and potential risks in energy exports in these countries may also affect the energy security risk level, policy practices that will eliminate the risks in energy exports may also positively affect the energy security risk level.

When the results obtained from the causality relationship between energy security and other variables (military expenditures, GDP, and energy export income) are evaluated in general, they demonstrate that they cannot be generalized across countries. However, it may be argued that energy security is an important policy tool that has important economic consequences for energy-exporting countries through its effects on different variables. In this direction, although various policy proposals can be made between countries, both indirect and direct effects should be considered. For example, energy security will be stimulated by stimulation of military expenditures in Saudi Arabia, and energy export revenues will also be stimulated through causality from energy security to export revenues. In addition to these two links, thanks to the bidirectional link between economic growth and energy security risk level, stimulation of energy security will stimulate economic growth. Therefore, it may be mentioned that there is an indirect effect of military expenditures on economic growth. In this way, policymakers may be providing different policy recommendations that may influence energy export revenues, economic growth, energy security, and military expenditures by making more connections between variables for energy-exporting countries.

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## Appendix

### Appendix 1 Panel causality test results (GDP vs. Energy export revenues)

| CN | Countries | Ho: GDP does not cause ENX | | | | Ho: ENX does not cause GDP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical values | | | Statistic | Critical values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 4.146 | 25.757 | 18.489 | 15.157 | 19.544 | 52.390 | 41.325 | 34.336 |
| 2 | Australia | 4.024 | 50.836 | 28.911 | 23.609 | 9.234 | 84.853 | 53.111 | 43.563 |
| 3 | Bahrain | 3.183 | 92.962 | 63.554 | 52.917 | 0.161 | 54.654 | 36.619 | 28.550 |
| 4 | Canada | 2.478 | 29.715 | 17.164 | 13.352 | 3.445 | 38.835 | 26.931 | 21.153 |
| 5 | Colombia | 43.073*** | 12.911 | 7.081 | 5.165 | 1.480 | 35.413 | 24.079 | 18.966 |
| 6 | Ecuador | 11.518 | 39.907 | 24.089 | 17.521 | 36.130 | 55.409 | 43.042 | 36.366 |
| 7 | Indonesia | 5.708 | 59.172 | 42.519 | 35.641 | 1.015 | 57.304 | 38.879 | 31.838 |
| 8 | Iran | 3.855 | 23.793 | 13.405 | 8.805 | 8.429* | 16.001 | 8.803 | 6.166 |
| 9 | Kuwait | 14.865 | 43.917 | 28.262 | 22.539 | 19.745 | 118.675 | 83.256 | 72.167 |
| 10 | Malaysia | 8.305 | 58.028 | 33.508 | 25.663 | 1.700 | 97.582 | 62.164 | 49.446 |
| 11 | Nigeria | 5.349 | 95.611 | 65.414 | 53.189 | 17.660 | 55.273 | 37.970 | 31.043 |
| 12 | Norway | 0.079 | 29.280 | 16.559 | 12.815 | 10.627 | 29.000 | 20.622 | 15.005 |
| 13 | Oman | 11.505*** | 10.755 | 7.068 | 4.980 | 0.008 | 65.206 | 40.304 | 32.996 |
| 14 | Paraguay | 0.626 | 43.881 | 27.553 | 20.198 | 2.721 | 64.651 | 46.769 | 38.673 |
| 15 | S. Arabia | 7.061 | 50.533 | 35.795 | 29.023 | 2.625 | 50.765 | 34.564 | 27.673 |
| 16 | Venezuela | 8.100* | 17.523 | 10.066 | 6.665 | 9.703** | 15.527 | 8.014 | 5.749 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*

### Appendix 2 Panel causality test results (GDP vs. Energy security)

| CN | Countries | $H_0$: GDP does not cause ES | | | | $H_0$: ES does not cause GDP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical Values | | | Statistic | Critical Values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 8.187 | 20.655 | 14.152 | 10.924 | 3.360 | 57.123 | 40.728 | 34.091 |
| 2 | Australia | 0.405 | 61.483 | 41.742 | 33.460 | 19.443 | 49.851 | 32.686 | 26.905 |
| 3 | Bahrain | 0.772 | 79.633 | 54.634 | 44.991 | 1.185 | 64.187 | 50.210 | 40.847 |
| 4 | Canada | 21.652*** | 19.482 | 13.167 | 9.843 | 0.022 | 11.605 | 7.851 | 6.122 |
| 5 | Colombia | 0.000 | 6.995 | 4.068 | 3.024 | 38.780*** | 7.641 | 4.649 | 3.379 |
| 6 | Ecuador | 7.830 | 43.286 | 23.605 | 18.635 | 37.410** | 43.485 | 29.475 | 24.950 |
| 7 | Indonesia | 0.660 | 68.950 | 45.708 | 34.279 | 30.155*** | 9.413 | 6.642 | 5.040 |
| 8 | Iran | 20.210*** | 16.968 | 9.780 | 6.718 | 191.734*** | 33.126 | 15.383 | 10.355 |
| 9 | Kuwait | 18.571** | 27.629 | 18.338 | 15.051 | 5.835 | 26.121 | 17.959 | 14.849 |
| 10 | Malaysia | 18.904 | 59.414 | 42.138 | 34.113 | 34.278* | 57.081 | 38.378 | 31.582 |
| 11 | Nigeria | 2.410 | 81.912 | 54.437 | 44.590 | 0.551 | 11.465 | 7.296 | 5.578 |
| 12 | Norway | 1.024 | 21.860 | 13.036 | 9.429 | 0.106 | 67.564 | 38.777 | 30.288 |
| 13 | Oman | 28.444*** | 7.608 | 4.611 | 3.328 | 16.885* | 26.358 | 18.433 | 15.480 |
| 14 | Paraguay | 0.000 | 47.876 | 27.008 | 21.273 | 1.705 | 4.460 | 3.153 | 2.561 |
| 15 | S. Arabia | 47.123** | 54.880 | 38.955 | 30.782 | 64.184*** | 22.884 | 14.420 | 10.877 |
| 16 | Venezuela | 9.784* | 17.884 | 10.510 | 7.002 | 37.693*** | 24.833 | 14.544 | 9.730 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*

***Appendix 3 Panel causality test results (Energy security vs. Energy export revenues)***

| CN | Countries | $H_0$: ES does not cause ENX | | | | $H_0$: ENX does not cause ES | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistic | Critical values | | | Statistic | Critical values | | |
| | | | 1% | 5% | 10% | | 1% | 5% | 10% |
| 1 | Algeria | 1.608 | 55.294 | 40.516 | 34.085 | 1.785 | 63.047 | 43.557 | 37.420 |
| 2 | Australia | 11.899 | 45.168 | 30.379 | 23.932 | 0.000 | 80.675 | 46.004 | 36.068 |
| 3 | Bahrain | 0.928 | 74.738 | 53.798 | 44.457 | 0.813 | 52.156 | 31.666 | 25.094 |
| 4 | Canada | 6.535* | 9.857 | 6.893 | 5.902 | 11.899** | 15.741 | 8.536 | 6.203 |
| 5 | Colombia | 10.300** | 18.307 | 9.130 | 6.246 | 0.285 | 10.508 | 6.868 | 5.346 |
| 6 | Ecuador | 0.454 | 48.784 | 30.499 | 23.741 | 2.982 | 57.404 | 43.809 | 36.369 |
| 7 | Indonesia | 4.598 | 16.261 | 9.935 | 7.639 | 0.472 | 64.508 | 43.976 | 34.045 |
| 8 | Iran | 0.058 | 50.209 | 22.552 | 15.392 | 15.368** | 15.562 | 9.114 | 6.433 |
| 9 | Kuwait | 2.952 | 27.836 | 17.869 | 15.247 | 17.463 | 122.876 | 77.316 | 65.960 |
| 10 | Malaysia | 29.246* | 49.675 | 31.466 | 25.125 | 5.972 | 82.185 | 50.852 | 40.986 |
| 11 | Nigeria | 5.036 | 12.279 | 7.199 | 5.782 | 13.823 | 46.121 | 32.434 | 24.425 |
| 12 | Norway | 7.486 | 65.512 | 40.879 | 30.402 | 0.107 | 13.937 | 7.422 | 5.487 |
| 13 | Oman | 17.393** | 27.433 | 17.029 | 13.508 | 16.553** | 18.442 | 10.867 | 8.166 |
| 14 | Paraguay | 4.144*** | 4.142 | 2.842 | 2.227 | 0.075 | 82.243 | 57.361 | 48.602 |
| 15 | S. Arabia | 9.341* | 18.977 | 11.009 | 8.214 | 21.016 | 54.203 | 38.211 | 35.380 |
| 16 | Venezuela | 0.752 | 21.367 | 12.504 | 9.473 | 4.308 | 21.321 | 10.380 | 6.564 |

Note: *, **, *** indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

*Source: Author*