

# Does Military Expenditure Impact Environmental Sustainability in Developed Mediterranean Countries?

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# Abstract

This study aims to examine the relationship between military expenditure and environmental sustainability in developed Mediterranean countries: Greece, France, Italy, and Spain. Sustainable economic growth is strictly related to energy consumption which leads to producing a higher level of carbon emissions. Besides, there may be a nexus between military expenditures and environmental pollution. This study focuses on developed Mediterranean countries since carbon emissions and greenhouse gas emissions are relatively high in these countries. Furthermore, France and Italy are the top countries in terms of total military spending. We investigate the relationship between military expenditure and carbon emissions using the Global Vector Autoregression model proposed by Pesaran, Schuermann, and Weiner (2004) and Dees et al. (2007) between 1965 and 2019. The empirical findings indicated that the relationship between carbon emission and military expenditure should be taken into account from a global perspective for environmental sustainability, and an increase in the global military expenditure seems to be very harmful to the global environment. It can be concluded that country-based prevents cannot provide the desired solution in combating environmental pollution.

## Introduction

The term sustainable development gained importance in the late 1980s in *The Brundtland Report*[1]. Since then, sustainable development became a goal for not only the development of nations, but also industrial and environmental sustainability and development (The Brundtland Report, 1987:13). The Brundtland report pointed out the urgency of searching new ways of production without ignoring the sustainable development without ignoring the well-being of environment, economies and people as a whole. Besides, sustainable development strategies should have been implemented on a global scale. In addition, sustainable development is a complicated progress that has the linkage between the past, today and the future. What happened in the past, what are the policies today, and what are the outcomes of the future should be taken into account while setting sustainable development strategies (Strange, T. and Bayley, 2008:24, 102). Also, there should be cooperative governance in developed and developing countries to secure their long-term well-being that requires a global contract between advanced and emerging economies to achieve global sustainability (de Lange, Wise and Nahman, 2010).

Sustainable development involves economic, social and environmental aspects (Ukko et al., 2019). Since sustainable development provides linkage between the well-being of the current generation and future generation, the concept of capital can be used to create this linkage. Financial capital, human capital, social capital, and natural capital are different forms of capital. Among all, natural capital is related to the environmental sustainability. Protecting the environment stands for preserving the flora and fauna as well as establishing sustainability for the next generations (Fuchs, Raulino, and Guerra, 2020:511). Also, human health can be badly impacted by smog, acid rainfall, and polluting atmosphere due to environmental degradation (Khan et al., 2019). Environment sustainability is related to energy consumption, economic and industrial activities, and transportation activities. Increasing energy efficiency, preferring renewable energy, applying innovative technologies in different industrial sectors to

protect the environment and using environmental-friendly vehicles are basic elements for alleviating environmental degradation. Nevertheless, despite all attempts, there is an escalating air and water pollution, increasing hazardous wastes and toxic materials. Particularly increasing energy consumption and transportation activities, and poisonous gases exhausted from the factories are the main sources of air pollution and global climate change. In this context, the effects of several factors such as energy consumption, economic growth, trade, urbanization, and foreign direct investment on environmental pollution have been widely examined in the literature. The main finding of the studies is that there is a positive relationship between economic variables and environmental pollution. Besides, there is scant empirical literature that focuses on the relationship between military expenditures and environmental pollution. However, it is well-known that the adverse effects of militarization on the environment are enormous, and the armed forces cause further contamination of the world. Actually, there is a trade-off between making more military spending to protect national security and protecting environment. Although there may be small cuts in military expenditures, there is always an increasing share in their total budget. It is a fact that military investments increase environment pollution. The effect of military expenditures on environmental degradation can be analyzed by making a distinction between the war period and the non-war period (peace period). In times of war, plant and natural living conditions, water and energy resources are destroyed, and even biological and chemical weapons are occasionally encountered. Large-scale construction and infrastructure investments are made to increase national security and defense power in times of peace. Investments in nuclear and military technologies, testing military equipment and weapons, transferring soldiers, military equipment, and weapons to cross-border areas may lead to severe environmental costs. Geopolitical competition-, short- or long-term cross-border military operations during non-war periods, military exercises, planes (especially fighter planes such as F-15 and F-16), helicopters (especially high-tech military helicopters), sea vessels, tanks, and armed vehicles increase energy consumption. Besides, the construction of military units and training areas, satisfying the demand for housing and military clothing of personnel, training and war preparation investments increase energy consumption (Jorgenson, Clark and Givens, 2012; Jorgenson and Clark, 2016: 507).

There is also a growing literature to examine the relationship between military expenditures and environmental pollution, but these studies generally investigate the relationship between the variables by using single country or panel data (Bildirici, 2017; Noubissi and Poumie, 2019; Ahmed et al., 2020). However, climate change is a global issue that threatens the whole world, and it requires international cooperation to reduce the harmful effect of global climate change, and environmental sustainability. Similarly, many global factors affect the defense spending of countries (such as global or regional terrorist attacks, defense spending by neighboring countries, global security risks). Therefore, the empirical analysis that does not take into account the spatial effect among the countries may produce misleading results.

In this context, Gould (2007) pointed that militarization is the single most destructive human endeavor of the environment. It is a fact that the militarization trends of the countries are highly related to geopolitical and regional factors. Besides, if the developed or center countries make defense expenditures, there is a

contagion effect on peripheral countries and they try to increase their defense expenditures as well. Following technological improvements and innovational technologies in the defense industry in developed countries, peripheral countries try to adopt those technologies to minimize the threats. Other developed or center countries also make investments in similar technologies to spread the risk coming from the countries that have developed new technologies. If there is a rising conflict within the region of the countries, the need to invest in defense increases enormously.

Similarly, global political cycles and economic, political, or military conflicts and treats among the regional countries accelerate militarization. All these reasons aggravate environmental degradation. It is a fact that the more military investment, the higher risk of environmental degradation. In this vein, technological improvements and innovative technologies are crucial in reducing the pollutive effects of militarization. Moreover, the aggregating effects of military expenditures on carbon dioxide emissions cannot be alleviated by the national defense policies of a single country. Regional and global cooperation is needed to control the negative impacts of defense expenditures. Also, environmental-friendly technologies should be used in the defense industry to minimize environmental degradation due to defense expenditures.

Reduction of the environmental costs of military expenditures can be possible with international cooperation. For international cooperation, all of the countries should be a volunteer and convinced. In this vein, the environmental cost of military expenditures needs to be explored at the country, regional and global levels. Findings from studies examining the relationship between defense expenditures and carbon dioxide emissions can be used as a critical data source in policy-making processes.

Figure 1 emphasizes the importance of analyzing military expenditures and carbon emissions from a global perspective. Figure 1 that illustrates world military expenditures and world carbon emissions for the periods of 1965-2019, shows that military expenditures have an increasing trend around the world, and carbon emissions accompany this. Also, the Pearson correlation for the variables is 93.4% that suggests the presence of a positive and strong relationship between military expenditures and economic growth.

This study aims to examine the presence of a relationship between military expenditure and environmental pollution in the selected developed Mediterranean countries: Greece, France, Italy, and Spain. The basic reason behind choosing the developed Mediterranean countries is that since military expenditures per capita are low in developing countries, the allocation of resources for the military expenditures is relatively low. As countries develop, they allocate more military spending from the general budget for defense spending. Hence, it will be more precise to evaluate the causality relationship between military expenditures, economic growth, and environmental pollution. The research is limited to the selected developed Mediterranean countries because France and Italy are in the top 15 military expenditure countries. Therefore, the findings of the study will provide an adequate explanation for the causality nexus between these variables. In addition, we preferred the level of carbon emissions for evaluating environment quality.

We employ the Global Vector Autoregression model proposed by Peseran, Schuermann, and Weiner (2004) and Dees et al. (2007) to examine the relationship between military expenditure and carbon emissions over the period of 1965-2019. This period is determined because of data constraints. The contribution of this paper is as follows: First, there is a limited number of papers investigating the adverse effects of military expenditures on environmental quality. Second, to the best of our knowledge, this study is the first attempt to examine the dynamic relationships among the variables in question for developed Mediterranean countries by using the GVAR model. Even if we focus on the developed Mediterranean countries, the GVAR model allows us to examine the relationship between military expenditures and carbon emissions from the global perspective. Therefore, we also examine the effects of military expenditures on carbon emissions from regional and global perspectives. To the best of our knowledge, the paper is also one of the first attempts that examine the relationship between military expenditures and carbon emissions in terms of a regional and global perspective and takes into account the spatial effects.

The rest of the paper is organized as follows: We present brief information on the military spending and carbon emissions of the developed Mediterranean countries in the following section. The third section presents a literature review. The fourth part contains data and empirical results.

### **Military Expenditures and Carbon Emission in Developed Mediterranean Countries**

Figure 2 illustrates the military expenditures as the percentage of GDP for the sample countries. Among the sample countries, Greece has the highest military burden. During the 2000-2018 period, Greece always had the highest rate of military expenditure concerning its GDP. Even in the local financial crisis period in 2009, Greece had the highest military spending ratio in GDP (3.2%). Particularly political conflicts with Turkey obligated Greece to increase military expenditures. France followed Greece as the second country with the highest military expenditure. France had the peak military expenditure with 2.48% in 2009. It was recorded as 2.38% in 2018. Italy and Spain followed Greece and France.

Table 1 represents the total military expenditures of sample countries and the ratio of military expenditures in their GDP. Among the developed Mediterranean countries, in 2019, Greece had the lowest military spending. Greece devoted \$5.5 billion and 2.6% of its GDP to military expenditures. Not just in the Mediterranean region, but also the world ranking France 1.6%, and Italy 0.8% of their GDP were devoted to military spending and they were recorded as two of the top 15 military spenders in the world. Spain was ranked 17th in the world military spenders ranking. According to Table 1, France had \$50.1 billion military expenditure, Italy \$26.8 billion, and Spain \$17.2 billion. Comparing with these records, the total military spending by all countries in North Africa was estimated as \$23.5 billion in 2019. Regional political conflicts also lead to making more military expenditures. The Gulf Cooperation Council countries, for example, continued to increase their military expenditures despite the fact that their GDP declined with sharp oil price decreases (Erdoğan, Çevik, and Gedikli, 2020)

**Table 1.** Total Military Expenditures of Sample Countries (2019, Billion \$) and Share in GDP (%)

Rank (2019)	Country	Spending (\$ bil.)	Change (%)		Spending as a share of GDP (%)	World share (%)
		2019	2018- 2019	2010- 2019	2019	2019
6	France	50.1	1.6	3.5	1.9	2.6
12	Italy	26.8	0.8	-11	1.4	1.4
17	Spain	17.2	0.9	-7.1	1.2	0.9
34	Greece	5.5	-0.4	-23	2.6	0.3

Source: SIPRI (2020:2)

Higher military expenditures may bring higher energy consumption and environmental degradation. In Figure 3, CO<sub>2</sub> emissions per capita in developed Mediterranean countries are illustrated.

Among the selected developed Mediterranean countries, Greece had the highest CO<sub>2</sub> emissions per capita ranking. High CO<sub>2</sub> emissions per capita ranking can be related to not only the weapon industry but also weak environment protection policies. Greece has a competitive tourism industry. The tourism sector may require significant infrastructure constructions, more transportation, and so, environmental destructions. Comparing with the other sample developed Mediterranean countries; France has the lowest CO<sub>2</sub> emissions per capita, although it is one of the greatest market players in the global defense industry. This can be explained in different ways: France does the military exercises and the tests of nuclear and chemical weapons it develops not within its borders, but generally in other countries with which it has agreements and in its former or ongoing colonies. Besides, through its multinational corporations, France carries its pollutive productions to the guest countries. Also, France makes great investments in technology. Innovations in the defense industry may be linked to less pollution. Furthermore, pollution is not merely related to the weapon industry. There are other production processes, sectors, and other reasons causing environmental pollution and increasing CO<sub>2</sub> emissions. According to the World Bank (2020) data, the developed countries reveal more CO<sub>2</sub> emissions than developing countries. In Turkey, as one of the developing Mediterranean countries, CO<sub>2</sub> emissions per capita escalated and recorded as 4.4 in 2014 and 5.24 in 2017. As one of the fastest-growing countries, Turkey had innovative investments in the defense industry, infrastructure, energy, industry, and construction sectors. However, comparing with the developed Mediterranean countries' CO<sub>2</sub> emissions, Turkey still has less pollution. In the same year, CO<sub>2</sub> emissions per capita were recorded at 3.97 in Algeria and 2.6 in Tunisia. Similar increases are also observed in GCC countries.

Natural resource-rich countries transfer more sources to military expenditures due to extreme security concerns. As public revenues have declined due to the decline in oil prices, military expenditures have been cut in many countries. Nevertheless, this is not valid for all countries. Even in some countries, despite the decrease in oil prices and volatility, military expenditures increase. The aim of this study is to

investigate the relationship between volatility in oil prices and military expenditures in GCC countries (United Arab Emirates, Bahrain, Qatar, Kuwait, Saudi Arabia, and Oman). The analysis period was determined differently for each country depending on the availability of data. UAE and Qatar were excluded from the analysis as the defense expenditures data of these countries could not be provided regularly. ARDL model was preferred for the research. According to the bound test results, there is a cointegration relationship between the variables in all countries. Besides, the long-term results showed that the volatility in oil prices in all countries, except for Bahrain, positively affects military expenditures. The error correction model indicated that there is a reverse relationship between oil price volatility and military expenditures. These findings indicated that despite the volatility in oil prices, military expenditures in GCC countries are not reduced.

## Literature Review

In the literature, many studies are investigating the relationship between military expenditure and economic growth. Studies in the first group are researches determining that military spending positively affects economic growth. In his study, Benoit (1978) investigated 44 least developed countries for the period 1950-1965. The author concluded that all countries included in the study had rapid economic growth with an increasing defense burden. He also concluded that the higher the defense expenditure, the greater the rate of growth. Using India's data for the period 1971-2010, Tiwari and Shahbaz (2013) examined the relationship between military expenditures and economic growth. According to the empirical results, military expenditures affect economic growth positively. Farzanegan (2014) investigated the impact of military expenditures on economic growth for the period 1959 - 2007 in Iran. Results revealed that there was unidirectional causality from the military expenditure to the economic growth.

Studies in the second group are researches determining that military spending negatively affects economic growth. Faini, Annez, and Taylor (1984) investigated 69 countries over the period 1952-1970 to analyze the effects of military spendings on output growth. The authors concluded that an increase of 10% in the defense burden leads to a reduction of annual growth by 0.13%. Deger (1986) pointed out the interrelation of multiple variables in military expenditure-economic growth nexus and expressed that military expenditures may have a stimulating effect in the structural change and technical modernization, but they may have a negative impact on national savings. Dunne and Vougas (1999) investigated the relationship between military expenditures and economic growth for the period 1964 - 1996 in South Africa. They demonstrated that military spending had a significant negative impact on economic growth. In their study, using data from 1964 to 1995, Batchelor, Dunne, and Saal (2000) found a significant negative effect on the manufacturing sector in South Africa.

Chang, Huang, and Yang (2011) examined the military expenditures-economic growth nexus for the period 1992 - 2006 in the 90 countries. Empirical findings show that military expenditures negatively affect economic growth. Using Myanmar's data for the 1975-2014 period, Ahmed et al. (2020) examined

the relationship between military expenditure, energy consumption, CO<sub>2</sub> emissions, and economic growth. The authors found that military expenditures reduced economic growth in the long run.

Studies in the third group are researches determining that economic growth affects military spending. Using data from the 1960-2001 period, Dritsakis (2004) examined the relationship between military expenditures and economic growth in Turkey and Greece. A unidirectional causality from economic growth to defense expenditure was detected in both countries. Gokmenoglu, Taspinar, and Sadeghieh (2015) examined the relationship between military expenditures and economic growth for the 1988 - 2013 period in Turkey. One way relationship from economic growth to military expenditure was identified. Topcu and Aras (2017) examined the relationship between military expenditures and economic growth for the period 1993 - 2013 in Central and Eastern European countries. According to the test results, there was a unidirectional causality from economic growth to military expenditures. In a similar study, Gokmenoglu, Taspinar and Rahman (2020) investigated the relationship between military expenditure, financial development, economic growth and environmental degradation in Turkey through the period 1960-2014. The authors indicated a unidirectional causality from military expenditure to CO<sub>2</sub> emissions and ecological footprint.

There are also studies that do not detect a relationship between variables. Abdel-Khalek, Mazloum, and Elzeiny (2020) investigated the relationship between military expenditure and economic growth, using India's data for the 1980 -2016 period. Results showed that there is no causal relationship between the variables. Some studies have had mixed results. Cappelen, Gleditsch, and Bjerkholt (1984) investigated the relationship between military expenditure and economic growth using data from 17 OECD countries for the period 1960-1980. According to the findings, except for the Mediterranean countries, military expenditures negatively affect economic growth in all countries included in the analysis. Dakurah, Davies, and Sampath (2001) analyzed the causality between military expenditures and economic growth, using the data from the 62 developing countries for the 1975-1995 period. Different results have been obtained for the individual countries covered. Kollias, Manolas, and Paleologou (2004) researched the relationship between the two variables, using data from the 1961 -2000 period of 15 member states of the European Union. The results are not the same for all countries.

Using the data from 137 countries for the period 1988-2005, Chen, Lee, and Chiu (2014) examined the causal relationship between the defense burden (defense expenditure as a share of GDP) and the real GDP per capita. Empirical findings showed that there is a bidirectional causal relationship between the variables. However, the results diverged depending on the country groups. Manamperi (2016) investigated the impact of military expenditure on economic growth in Greece and Turkey for the period 1970 - 2013. The test results indicated that military expenditure had a significant negative impact on economic growth in Turkey. On the contrary, the impact of military expenditure on economic growth was not significant in Greece. Kollias et al. (2017) investigated the relationship between military expenditures, economic growth, and investment for the period 1961 - 2014 in the 13 Latin American countries. The same result could not be found for all countries. In another study using data from 65 countries for the period 1971 - 2014, Kollias and Paleologou (2019) achieved similar results.

Although there is a large literature investigating the relationship between military expenditures and economic growth, the number of studies investigating the effects of military expenditures on environmental degradation is very few. Therefore, instead of classifying the literature, the findings of the limited studies will be summarized.

Using the data of 72 countries, Jorgenson, Clark, and Kentor (2010) investigated the effect of military variables (military expenditures per soldier and number of military personnel) on CO<sub>2</sub> emissions in the period 1970 - 2000. Based on the test results, it was concluded that military variables affect CO<sub>2</sub> emissions positively. Clark, Jorgenson, and Kentor (2010) used the energy consumption variable instead of CO<sub>2</sub> emissions in a similar study for 68 countries in the same period. The authors found that military expenditures per soldier and the number of military personnel have increased energy consumption. Jorgenson and Clark (2016) investigated the relationship between military variables (military expenditures as a percent of total gross domestic product and military personnel as a percent of the total labor force) and CO<sub>2</sub> emissions for 81 countries in the period 1990 - 2010. Empirical results showed that military expenditures increase CO<sub>2</sub> emissions more in developed OECD countries than non-OECD developing countries.

Bildirici (2017) investigated the relationship between CO<sub>2</sub> emissions, military expenditure, economic growth, and energy consumption for the period 1960 - 2013 in the USA and found a positive and statistically significant relationship between CO<sub>2</sub> emissions and military expenditures. One way causality from military expenditure to CO<sub>2</sub> emissions, from energy consumption to CO<sub>2</sub> emissions, and from military expenditure to energy consumption all without feedback was detected. In another study for the USA, Bildirici (2017) identified bi-directional causality between military expenditure and biofuel consumption and unidirectional causality from military expenditure to CO<sub>2</sub> emissions.

Using the data of 54 African countries, Noubissi and Poumie (2019) investigated the effects of military expenditure on environmental pollution in the period 1980 - 2016. Empirical findings indicated that military expenditures have positive effects on carbon dioxide, nitrous oxide (NO<sub>2</sub>), and methane (CH<sub>4</sub>) emissions. Sohag, Taşkın, and Malik (2019) investigated the effect of cleaner energy, technological innovation, and military expenditure on green economic growth for the period 1980 -2017 in Turkey. Findings show that military expenditure negatively affects green economic growth.

Using data from 1995 to 2017, Zandi, Haseeb, and Abidin (2019) investigated the relationship between corruption, democracy, military expenditure, and CO<sub>2</sub> emissions in Malaysia, Indonesia, Philippines, Thailand, Singapore, and Vietnam. A positive and significant effect of military expenditure and corruption on CO<sub>2</sub> emissions was found. Qayyum, Anjum, and Sabir (2021) explored the impacts of armed conflicts and militarization on the environment in South Africa, spanning the period 1984-2019. The authors confirmed that there was a causality from armed conflicts and militarization to ecological footprint. Besides, military expenditures had negative impacts on environmental quality both in the long and short term. Solarin, Al-mulali, and Ozturk (2018) examined the relationship between military expenditures and

CO2 emissions for the period 1960-2015 in the USA. Test results showed that military expenditure had a mixed effect on CO<sub>2</sub> emissions.

## Data And Empirical Results

We investigate the dynamic relationship between military expenditure and carbon emission using the GVAR model for the periods of 1965-2019.[1] As in Ahmed et al. (2020) and Ozturk and Acaravci (2010), we consider employment ratio and trade openness (the sum of export and import to GDP ratio) as control variables in the estimations.[2] Furthermore, the studies in the literature show that there is a significant relationship between economic growth, energy consumption, military expenditures, and carbon emission. However, considering all variables in the VAR model leads to an endogeneity problem because all variables will be endogenous. To avoid this problem in the estimation procedure, we obtain world GDP per capita and world energy consumption and treat these variables as a global variable in the VAR model estimation. This model setup allows us not only to avoid endogeneity problems in the estimation but also to take into account the effects of economic growth and energy consumption on military expenditures and carbon emission. The name, the definition, and the sources of the variables are presented in Table 2. We express all series in natural logarithms except for employment and trade.

**Table 2: Variables Definition**

<b>Domestic Variable</b>	<b>Definition</b>	<b>Sources</b>
<i>me</i>	Military expenditure per capita	SIPRI
<i>co</i>	Carbon dioxide emission per capita	BP Statistical Review
<i>emp</i>	Number of persons engaged / Population	Penn World Table 10
<i>trd</i>	Sum of merchandise exports and imports / GDP	Penn World Table 10
<b>Global Variable</b>	<b>Definition</b>	<b>Sources</b>
<i>y</i>	World GDP per capita (constant 2010 US\$)	World Development Indicators
<i>ec</i>	World Primary Energy Use	BP Statistical Review
<i>oil</i>	WTI crude oil price	US Energy Information and Administration

Our GVAR model consists of 24 countries from different regions of the world. Four countries (France, Greece, Italy, and Spain) are classified as developed Mediterranean countries in this study. We also consider six countries from Europe to investigate the presence of geographical interactions. We present countries and regions in Table 3.

**Table 3: Countries and Regions in the GVAR Model**

	Developed Mediterranean	Europe	Rest of the world
<b>USA</b>	France	Austria	Argentina
<b>UK</b>	Greece	Belgium	Australia
<b>Japan</b>	Italy	Finland	Brazil
<b>China</b>	Spain	Germany	Canada
		Netherlands	India
			Indonesia
			Israel
			Korea
			Mexico
			South Africa
			Turkey

Since the aim of the study is to examine the relationship between military expenditure and environmental pollution in developed Mediterranean countries, we just report analysis results for these country groups. [3] However, we also examine the relationship between military expenditure and environmental pollution from regional and global perspectives by using impulse response analysis.

The descriptive statistics for the developed Mediterranean countries are presented in Table 4. The results in Table 4 show that the panel mean of log of military expenditure per capita is 6.107. While the highest military expenditure was obtained from France, Spain has the lowest military expenditure over the sample countries. The panel mean of per capita carbon emission is found to be 1.886 and we determine that France produces the highest carbon emission whereas Spain has the lowest carbon emission. These findings indicate that France has the highest military expenditures and also produces the highest carbon emission among the developed Mediterranean countries. Also, we determine that the mean of employment ratio and trade openness is 0.395 and 0.404, respectively, for the sample countries.

**Table 4: Descriptive Statistics for Mediterranean Countries**

Variables	Mean	Std Dev.	Min	Max
<i>me</i>	6.107	1.634	2.621	9.265
<i>co</i>	1.886	0.270	0.971	2.353
<i>emp</i>	0.395	0.025	0.306	0.462
<i>trd</i>	0.404	0.159	0.120	0.730

The Pearson correlation coefficients for the variables are presented in Table 5. The results in Table 5 suggest that there is a positive and statistically significant correlation between carbon emissions and military expenditure. In addition, military expenditure and carbon emissions are positively correlated with employment ratio and trade openness.

We also examine the presence of cross-sectional dependence by using the CD test suggested by Pesaran (2015) and present the results in Table 5. The CD test results in Table 5 show that the null hypothesis of weak cross-sectional dependence can be rejected for all variables at a 1% significance level. The presence of cross-sectional dependence among the countries suggests estimating a GVAR model because the relationship between military expenditure and environmental pollution is not the only country-based issue, but also there is a global dimension of this relationship.

**Table 5: Correlations and CD Test Results**

Correlations	<i>me</i>	<i>co</i>	<i>emp</i>	trade	CD test
<i>me</i>	1.000				18.117 [0.000]
<i>co</i>	0.377***	1.000			17.915 [0.000]
<i>emp</i>	0.432***	0.279***	1.000		18.126 [0.000]
<i>trd</i>	0.655***	0.292***	0.477***	1.000	17.974 [0.000]

Note: \*\*\* indicates statistically significant correlation at 1% level. [.] is p-value.

We consider the trade weights to create country-specific variables , , , and in the GVAR model. As in Peseran, Schuermann, and Weiner (2004) and Dees et al. (2007), we use fixed trade weights that are calculated as the average trade flows over the three years 2012-2014. The time-series data for the regions are constructed via cross-section weighted means of country-specific variables and we calculate the cross-section weights by using the average Purchasing Power Parity GDP over the 2012–2014 period.

Military expenditure and carbon emissions that are the country-specific variables, log of world GDP per capita, log of world energy consumption, and log of oil prices are treated as exogenous in all countries. Since the aim of the study is to examine the relationship between military expenditure and environmental

pollution in the developed Mediterranean countries, we just report analysis results for developed Mediterranean countries.

We start our analysis by first investigating the integration order of the variables. Hence, we employ both ADF and PP unit root tests and the test results suggest that all variables are stationary at first difference. In this context, we examine the presence of long-run relations among country-specific, foreign and global variables by using the Johansen cointegration test. It should be noted that we consider the trace statistics when we employ the Johansen cointegration test and we decide cointegration relation among the variables at the 5% significance level.

To conduct the Johansen cointegration test, we first estimate the VARX\* model, and optimal lag length is determined as the Akaike information criterion (AIC). We present optimal lag lengths and the number of cointegration relations in Table 6. According to the results in Table 6, the VARX\* (2, 1) model specification is found to be adequate to render the residuals white noise for all countries. Furthermore, we determine that there is at least one cointegration relationship between variables. For instance, while one cointegration vector is determined for Greece, it is concluded that there are two cointegration vectors for Italy and three cointegration vectors for France and Spain.

**Table 6: VARX\* order and number of cointegration relationships in the country-specific models**

Country	$p_i$	$q_i$	#Cointegrating relations
France	2	1	3
Greece	2	1	1
Italy	2	1	2
Spain	2	1	3

The main assumption underlying the use of the GVAR model is that domestic variables are affected by country-specific foreign variables. Therefore, this assumption requires testing whether country-specific foreign variables are weakly exogen. As in Peseran, Schuermann, and Weiner (2004) and Dees et al. (2007), we employ the weak exogeneity test using an  $F$ -test by imposing zero restrictions on the country-specific foreign variables and present the test results in Table 7. The results in Table 7 show that the weak exogeneity of foreign variables and global variables is not rejected in all developed Mediterranean countries. These results suggested that country-specific foreign variables are weakly exogenous, and this is consistent with the main assumption of the GVAR modeling.

**Table 7: F-statistics for testing the weak exogeneity of the country-specific foreign variables and oil prices**

Country	Critical Value at 5% Level	Foreign Variables					
		<i>me</i> *	<i>co</i> *	<i>y</i> *	<i>ec</i> *	<i>poil</i> *	
France	F(3,39)	2.845	1.345	1.022	0.856	1.057	0.238
Greece	F(1,41)	4.078	0.042	0.001	0.119	0.310	0.122
Italy	F(2,40)	3.231	0.275	1.858	1.216	1.242	0.304
Spain	F(3,39)	2.845	0.451	0.619	1.411	1.503	0.511

The contemporaneous effect of foreign variables on their domestic counterparts is presented in Table 8. The results in Table 8 show the elasticity between domestic and foreign variables. According to Table 8, all of them are determined as positive and statistically significant, and this finding provides evidence in favor of international linkages between domestic and foreign variables. In this context, a 1% increase in foreign carbon emissions causes to 1.31% increase in the carbon emissions of France. Spain is determined as the most affected country by an increase in foreign carbon emissions.

Similarly, it has been determined that increased military spending positively affects domestic variables in developed Mediterranean countries. The effect of foreign military expenditure on domestic one is determined as highest in France. A 1% increase in the global military expenditure leads to a %1.28 increase in the military expenditure in France.

**Table 8: Contemporaneous Effects of Foreign Variables on Their Domestic Counterparts**

Country	Domestic Variables	
	<i>me</i>	<i>co</i>
France	1.280 [13.585]	1.319 [6.099]
Greece	0.504 [3.170]	0.585 [2.021]
Italy	0.957 [4.830]	0.856 [4.736]
Spain	0.987 [17.801]	1.418 [3.873]

Notes: [.] is the t statistics that are calculated by using the Newey-West covariance matrix.

To determine the dynamic relationships among the variables, we employ impulse-responses analysis by using VECMX that is presented in Equation (9).<sup>[4]</sup> Note that we calculate the GIRF that is not affected by

the ordering of the variables. We conduct four different impulse-responses analyses in this study. First, we focus on a country-based relationship and examine the responses of domestic carbon emission to a domestic military expenditure shock in developed Mediterranean countries. Secondly, we focus on the effect of regional military expenditure shock on domestic carbon emissions. Hence, we calculate the responses of domestic carbon emission in developed Mediterranean countries to a regional military expenditure shock in Europe. Third, we examine the regional relationship between carbon emissions and military expenditure. In this context, we use regional classification in Table 3 and examine the responses of regional carbon emission to an unexpected shock in military expenditure in the European region. Finally, we also examine the regional responses of carbon emission to an unexpected global military expenditure shock. Therefore, we can examine the reaction of carbon emission to an unexpected military expenditure shock in terms of both country-based, regional and global perspectives.

We present country-based impulse responses analysis results for the relationship between carbon emission and military expenditure in Figure 4. Note that, the results in Figure 4 show responses of carbon emission to a one standard error positive shock in military expenditure. According to results in Figure 4, while the initial responses of carbon emission to an unexpected military expenditure shock are positive in Spain, they turn to negative after the third year. Although carbon emission initially reacts negatively to a military expenditure shock in France, these responses turn positive in the second year. On the other hand, the responses of carbon emission in Greece to an unexpected military expenditure shock are negative. Although the carbon emission initially reacts negatively to an unexpected military expenditure shock in Italy, the responses are found to be positive between 5 and 15 years.

These results suggest that there is a positive relationship between military expenditure and carbon emission in the short-run and medium-run for all countries except for Greece. This is consistent with empirical results documented in Sana and Neila (2016) who found that carbon emission is positively affected by military expenditure. Furthermore, our results are similar to the empirical findings of Bildirici (2017) who found a positive and significant relation between military expenditure and carbon emission for the US.

Next, we examine the responses of carbon emission in the developed Mediterranean countries to a positive military expenditure shock in the Europe region and present the results in Figure 5. The results in Figure 5 show that the initial responses of carbon emission to an unexpected military expenditure shock in the Europe region are negative in France and Italy. However, the responses of carbon emissions in these countries turn positive and have reached their highest value in the second year. On the other hand, the reactions of carbon emission to unexpected military expenditure shock are positive in Greece and Spain. These findings are very interesting because country-based impulse responses analysis results in Figure 4 show that the responses of carbon emission to an unexpected military expenditure shock are negative in the long run in all countries except for France. These results emphasize the importance of international linkages between developed Mediterranean countries and Europe in terms of carbon emission and military expenditure relationship. Therefore, it can be said that the relationship between carbon emission and military expenditure in developed Mediterranean countries cannot be considered

only domestic and foreign military expenditure in the same region play an important role in carbon emission in developed Mediterranean countries.

Figure 6 present the responses of carbon emission in developed Mediterranean countries to an unexpected positive global military expenditure shock. According to results in Figure 6, the initial responses of carbon emission in France to a global military expenditure shock are negative but they turn positive after the 5th year and remain positive up to the 15th year. Hence, it can be said that carbon emission in France is positively affected by global military expenditure in the medium and long run. On the other hand, the responses of carbon emission to an unexpected global military expenditure shock are found to be positive in Greece, Spain, and Italy.

When we evaluate both results in Figure 4 and Figure 5, it can be said that domestic carbon emission is more affected by regional military expenditures than domestic ones and this result emphasizes the importance of regional policies for combating environmental pollution. On the other hand, comparing the results in Figure 5 and Figure 6, it is evident that the responses of the carbon emission to an unexpected global shock in the military expenditure are considerably higher than the responses of carbon emission to an unexpected regional shock in the military expenditures. These results suggest that environmental pollution is a global issue and hence the reduction of carbon emission should be considered from a global perspective.

After confirming the global importance of the relationship between carbon emission and military expenditure in country-based analysis, we take the analysis one step further and examine the relationship between carbon emission and military expenditure in terms of regional and global. Hence, first, we calculate the responses of carbon emission in different regions to an unexpected military expenditure shock in Europe and present the results in Figure 7. The results in Figure 7 clearly show that the responses of carbon emission to an unexpected military expenditure shock in Europe are positive in all regions except for China and Japan. On the other hand, carbon emission in China and Japan reacts negatively to military expenditure shock in Europe. These results can be explained by the distance between the regions because Japan and China are farther from Europe than other countries or regions and this finding again confirms the importance of the spatial effect.

This result indicates that when an unexpected increase in military expenditure in Europe, not only carbon emissions in Europe but also carbon emissions in different parts of the world significantly increase.

Finally, we examine the regional responses of carbon emission to global military expenditure shock and present the results in Figure 8. Except for Japan, carbon emission in all regions or countries reacts positively to unexpected global military expenditure shock. It is well known that Japan is an island state and therefore it can be expected the less spatial effect than the other countries in the sample. Note that although the initial responses of carbon emission in Europe and developed Mediterranean countries are negative, they turn positive after the second year, and then they remain positive.

Overall, the results for the regional analysis show that an increase in military expenditure not only increases carbon emission in their region but also in another region. This finding is confirmed by the global shock analysis. These results suggest that an increase in the global military expenditure seems to be very harmful to the global environment, and hence it can be said that country-based prevents in combating environmental pollution cannot provide the desired solution.

## Conclusions

This paper aims to investigate the dynamic relationship between military expenditure and carbon emissions in developed Mediterranean countries, namely Greece, France, Italy, and Spain. We focused on developed Mediterranean countries because carbon emission and greenhouse gas emission are relatively high, specifically in France and Italy. Also, France and Italy are two of the top countries in the world in terms of total military spending. We investigated the relationships among military expenditure and carbon emission using the impulse-responses analysis depends on estimations of the Global Vector Autoregression model.

We conducted four different impulse-responses analyses in this study. First, we focused on a country-based relationship and examined the responses of domestic carbon emission to a domestic military expenditure shock in developed Mediterranean countries. Secondly, we focused on the effect of regional military expenditure shock on domestic carbon emissions. Third, we examined the regional relationship between carbon emissions and military expenditure. Finally, we analyzed the regional responses of carbon emission to an unexpected global military expenditure shock.

The country-based impulse-responses analysis results showed that there is a positive relationship between military expenditure and carbon emission in the short-run and medium-run for all countries except for Greece. This finding is consistent with empirical results documented in Ben Afia and Harbi (2018) and Bildirici (2017).

Regional impulse-responses analysis results show that there are strong international linkages between the developed Mediterranean region and Europe because the responses carbon emission in the developed Mediterranean region to a positive military expenditure shock in Europe is positive. This result indicates that carbon emission in developed Mediterranean countries is not only affected by domestic military expenditure but also foreign military expenditure in the same region.

Similarly, we found that carbon emissions in developed Mediterranean countries react positively to an unexpected positive global military expenditure shock. Furthermore, it was determined that domestic carbon emission in the developed Mediterranean countries is more affected by regional military expenditures than domestic ones, and this result emphasizes the importance of regional policies for combating environmental pollution. Also, the responses of the carbon emission to an unexpected global shock in the military expenditure are considerably higher than the responses of carbon emission to an

unexpected regional shock in the military expenditures. These results suggested that environmental pollution is a global issue, and hence the reduction of carbon emission should be considered from a global perspective.

Overall, the results for the regional analysis showed that an increase in military expenditure not only increases carbon emissions in their region but also in another region. This finding is confirmed by the global shock analysis. These results suggest that an increase in the global military expenditure seems to be very harmful to the global environment, and hence it can be said that country-based prevents in combating environmental pollution cannot provide the desired solution.

Some of the prominent policy recommendations to reduce the impact of carbon dioxide emissions due to defense spending are as follows:

- In addition to the national defense expenditures of the countries in the Mediterranean region, the defense expenditures of other countries in the same region affect the carbon emissions. According to this result, the measures to be taken by a single country are not sufficient enough. To reduce the negative impacts of military spending on environmental quality, certain measures should be initiated by regional and global cooperation. The measures should be parallel to the sustainable environment strategies.
- Environment-friendly technological innovations which supports environmental sustainability should be encouraged in the defense industry. Also, less polluting defense industry investments should be supported at the national level. And finally, international investment collaborations in this field should be developed.

## Declarations

**Ethics approval and consent to participate:** Not applicable.

**Consent to participate:** Not applicable.

**Consent to publish:** Not applicable.

**Availability of data and materials:** It is available on request.

**Competing interests:** The author declares no competing interests.

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**Authors' contributions:**

SE: Supervision, Writing, Review; AG: Writing-Original draft, Review and editing; EIC: Methodology, Formal analysis; MAÖ: Resources, Writing

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## Figures

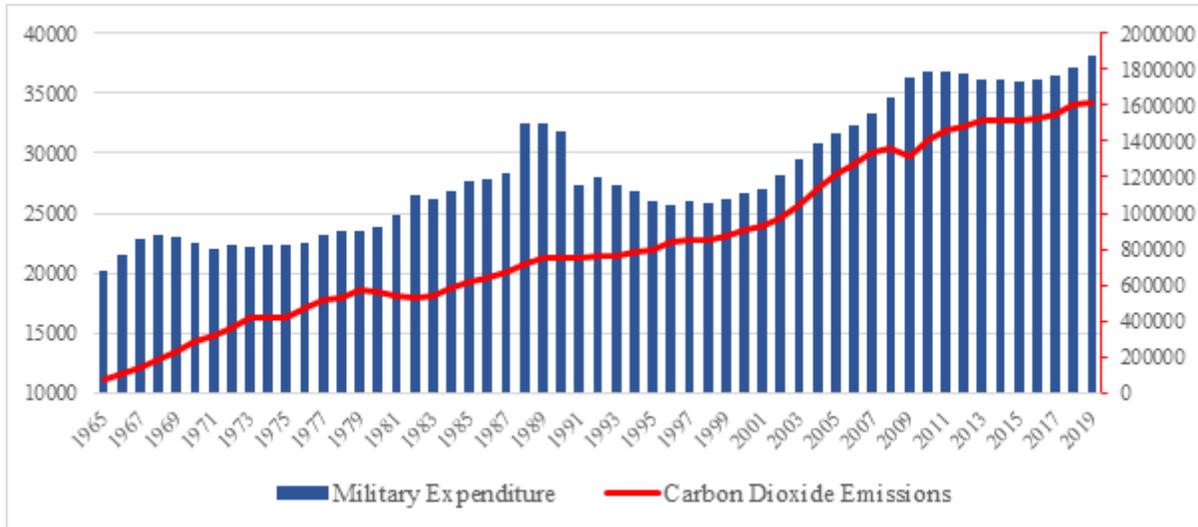


Figure 1

Global CO2 Emissions (million tons) and Military Expenditures (constant US\$ million) Note: Left scale is the carbon emissions, and the right scale is the military expenditures. The data source is SIPRI and World Bank World Development Indicators.

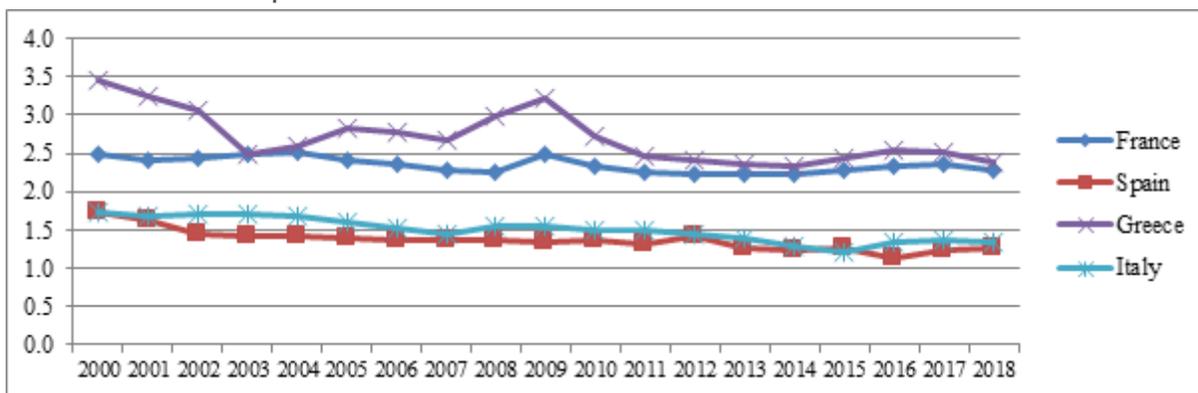
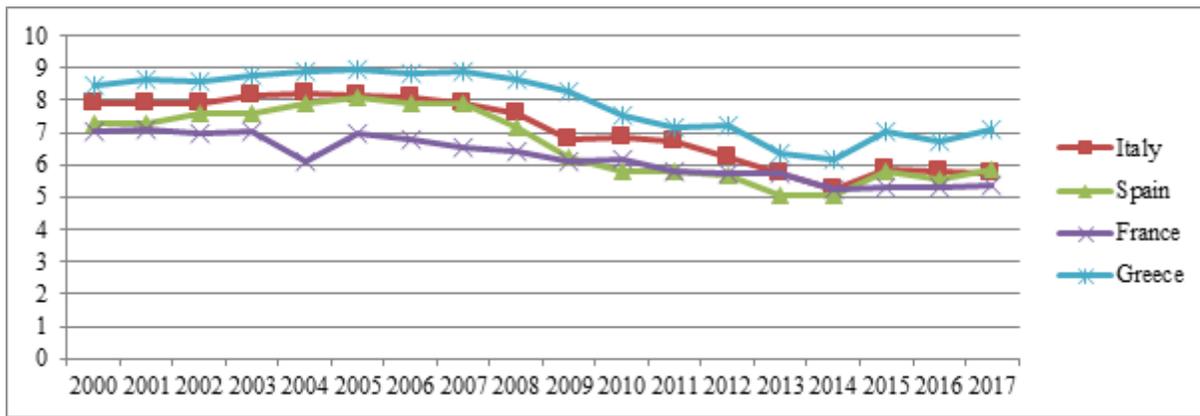


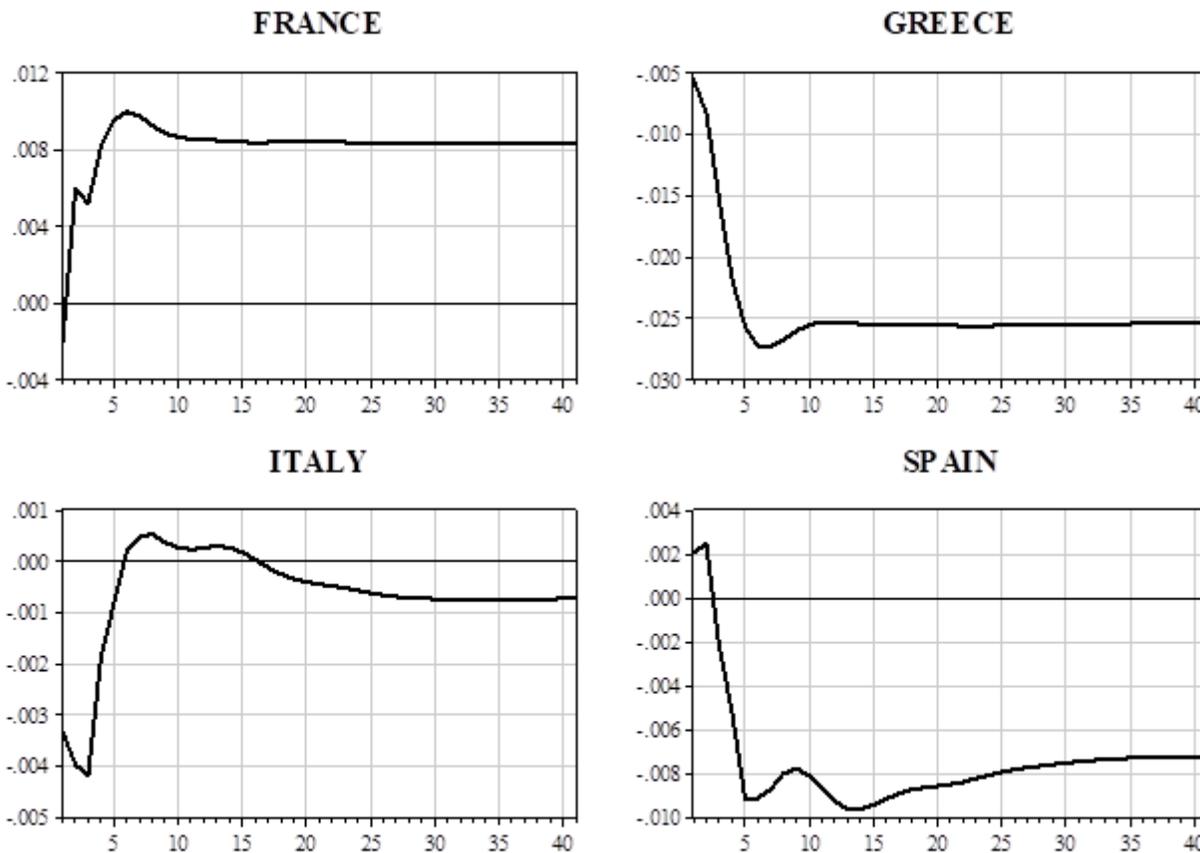
Figure 2

Military Expenditure (% GDP) of Selected Developed Mediterranean Countries (2000-2018) Source: World Bank Data (2020)



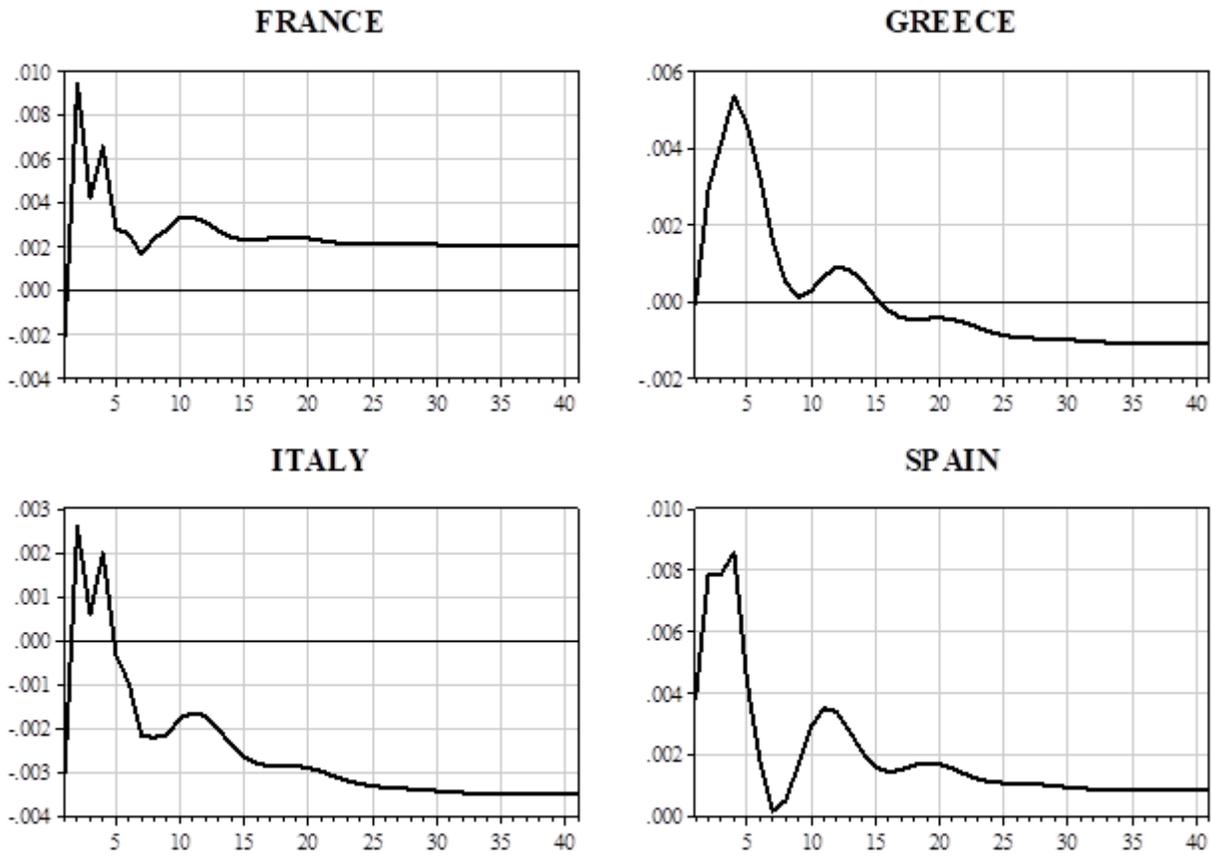
**Figure 3**

CO2 Emissions (metric tons per capita) for Developed Mediterranean Countries (2000-2017) Source: World Bank Data (2020); Our World in Data (2020)



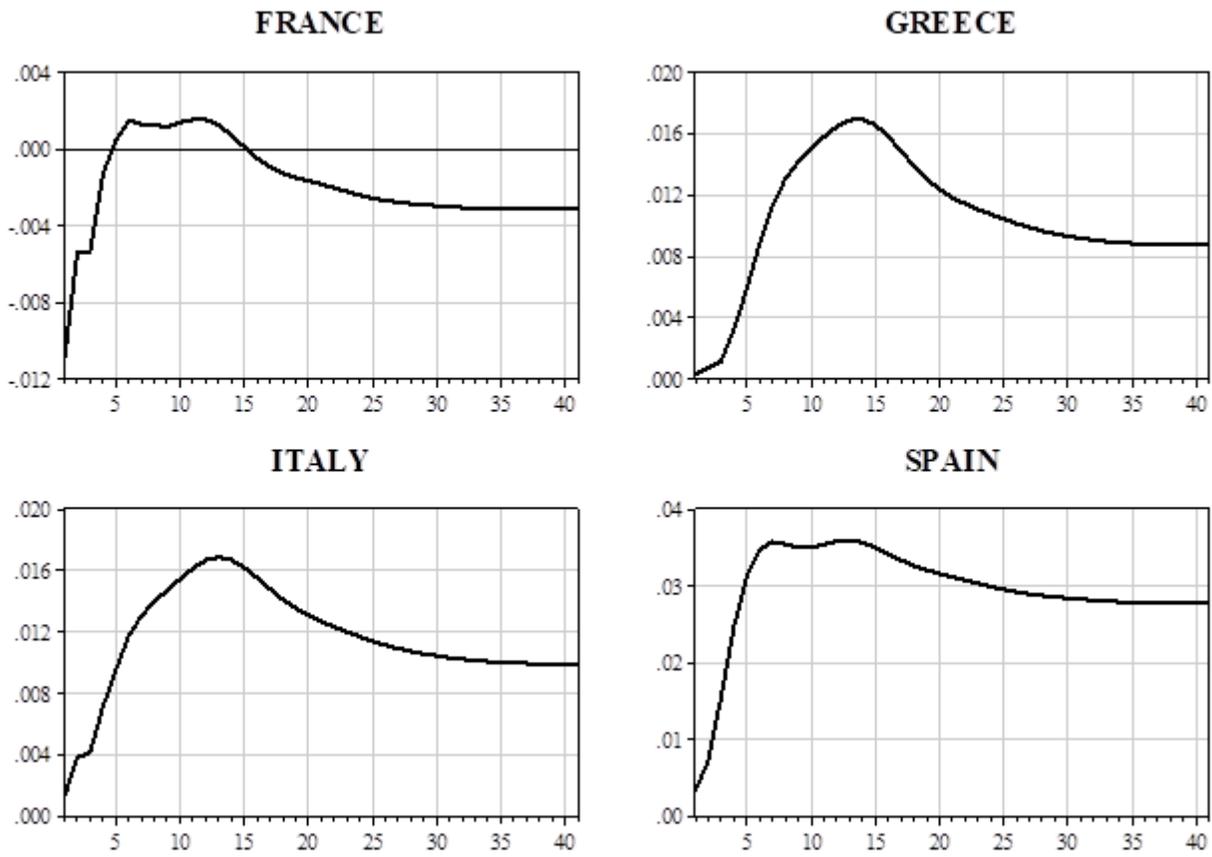
**Figure 4**

Responses of Carbon Emissions to a Shock in Military Expenditures in Developed Mediterranean Countries



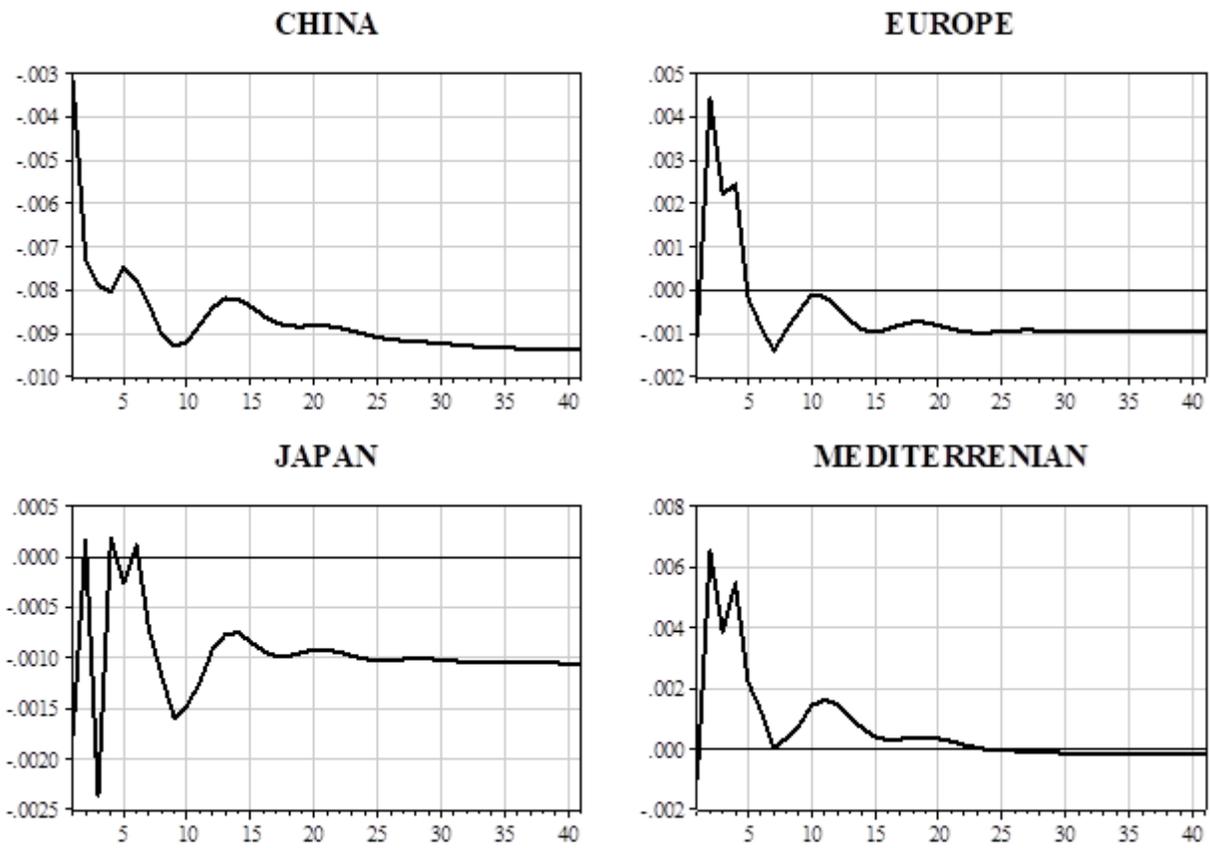
**Figure 5**

Responses of Carbon Emissions in Developed Mediterranean Countries to a Regional Military Expenditure Shock in Europe



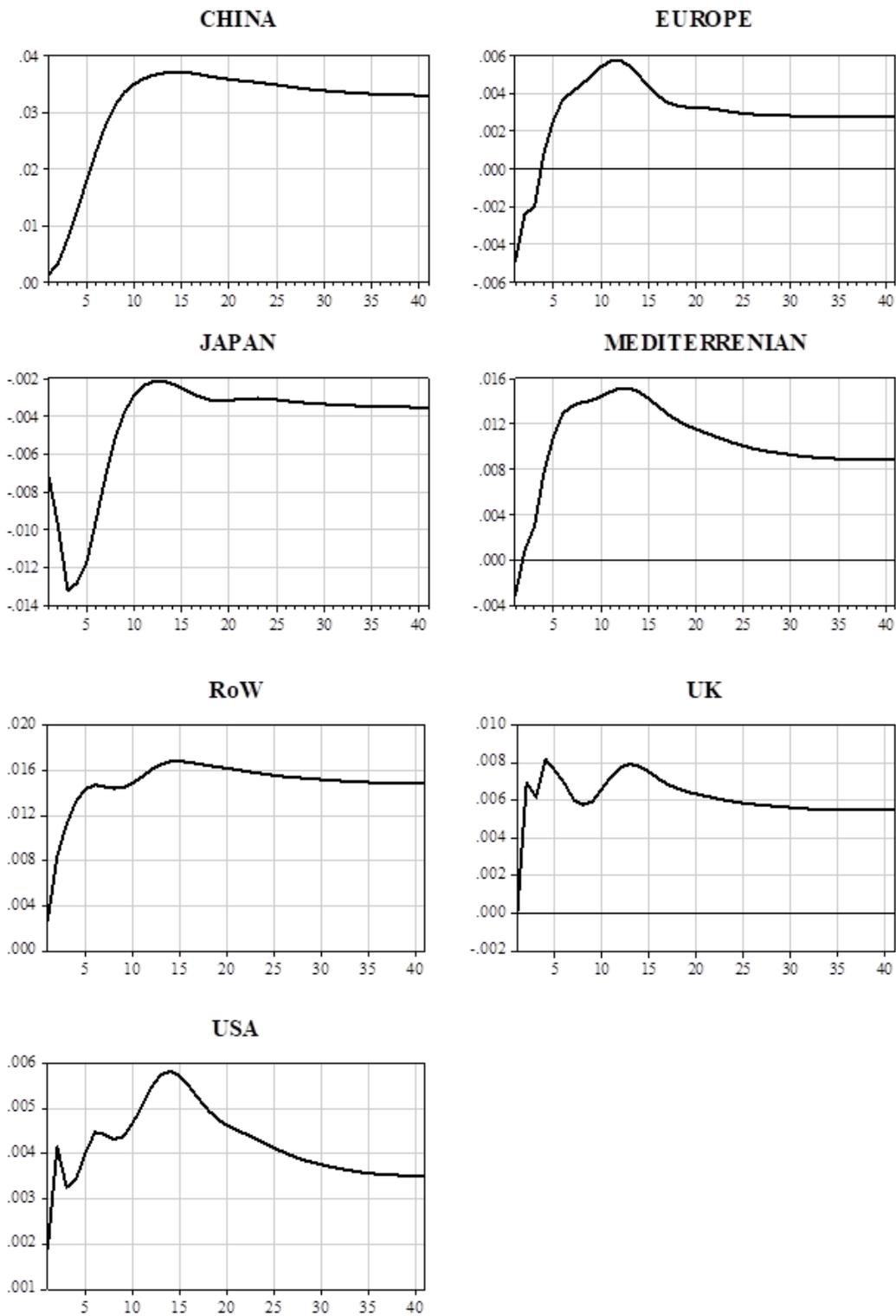
**Figure 6**

Responses of Carbon Emissions in Developed Mediterranean Countries to a Global Military Expenditure Shock



**Figure 7**

Responses of Regional Carbon Emissions to a Regional Military Expenditure Shock in Europe



**Figure 8**

Responses of Regional Carbon Emissions to a Global Military Expenditure Shock

## Supplementary Files

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