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## Guns versus butter for economic growth: a disaggregated analysis of the impact of military expenditure

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# Guns versus butter for economic growth: A disaggregated analysis of the impact of military expenditure.

## Abstract

Few empirical studies have applied a disaggregated analysis of the impact of military expenditure on economic growth. The novelty of this study lies in its use of various econometric and statistical methods to assess the impact of disaggregated defence spending on economic growth in a developed economy like Greece, which has consistently spent over 2% of its GDP on military expenditures. This study employs the latest data from 1980 to 2023 to improve precision and relevance in the analysis. The findings possess substantial practical and theoretical ramifications. First, military expenditure stimulates economic growth in the short run but impedes it in the long run. Second, our research indicates that military personnel spending exerts the most pronounced and contradictory impact on economic growth relative to other categories of the military budget. Finally, the Granger causality results confirm that a robust feedback relationship exists between economic growth and military spending. In light of these results, it is essential for a country to follow a rational spending approach for national security and to implement a balanced spending strategy that promote the production of domestic armaments and technology, enhance human resources, and improve the labor market after military service, thus minimizing inelastic expenditures such as wages and pensions.

**Keywords:** Defence Spending, Economic Growth, Greece, Time Series Analysis, ARDL.

**JEL Classifications:** H56; O40; C22; F5

## 1. Introduction

The effect of military spending on economic growth remains an underexplored topic in development economics despite a vast body of literature. The increase in empirical studies is driven by improved data availability and advanced econometric techniques, enabling more efficient analysis.

Military expenditures reflect a nation's security priorities and play a crucial role in both developing and developed economies. Following the 2008 financial crisis and the pandemic, many NATO countries reduced defence budgets. However, Russia's recent invasion in Ukraine has reignited focus on military spending, leading to significant increases. Greece, alongside the United States, France, the United Kingdom, and Türkiye, has consistently allocated over 2% of its GDP to defence for the past four decades.

In fact, Greece constitutes a compelling example for analysing the influence of military funding on economic growth. Despite the prolonged economic crisis from 2008 to 2016 and prevailing economic and financial challenges, Greece continues to allocate substantial resources towards its military expenditures to protect its national sovereignty. Economic objectives, security requirements, and Türkiye's assertive actions in the Mediterranean Sea have prompted

Greece's significant defence expenditures. Considering Greece's distinct situation, the recommendations of this study may offer significant insights for strategic decisions about defence expenditure and resource distribution.

Numerous studies have examined the link between defence spending and economic growth. Benoit's 1978 study found a significant correlation, but reassessments using advanced methods, alternative theories, and broader analyses have challenged this. Despite extensive research since, no consensus has been reached.

Recent studies show mixed results on the impact of military spending on economic growth. Mohanty et al. (2020), Dimitraki and Win (2021), Ajala and Laniran (2021), Emmanouilidis and Karpelis (2021), Aijaz Syed (2021), and Ullah et al. (2021) find a positive effect, while Becker and Dunne (2023), Ahmed et al. (2020a; b), Azam (2020), and Dada et al. (2023) report a negative impact. Others, including Kollias and Tzeremes (2022), Maher and Zhao (2022), Rehman et al. (2023), and Emmanouilidis (2024), remain inconclusive. According to Dunne and Uye (2010) the differing conclusions can be attributed to factors such as theoretical frameworks, model variations, estimation methods, and analysis periods. The lack of consensus, along with advances in econometrics, continues to drive research toward a more robust and reliable understanding.

Recent studies focus on the defence spending-economic growth relationship, particularly in developing economies (e.g., Ahmed et al., 2020a, 2020b; Dimitraki and Win, 2021; Rehman et al., 2023). Panel studies in developed economies (e.g. Becker & Malesky, 2017; Dunne & Smith, 2020; and Becker and Dunne (2023) assess military expenditure's economic impact. However, policy insights remain limited due to the country-specific nature of this relationship, shaped by historical, geopolitical, economic, and institutional factors.

Importantly, recent single-country studies focused on the economic impact of military spending in developed economies are scarce. For instance, Dimitraki and Emmanouilidis (2023) find that, in Spain, the effect varies by period, being positive from 1954–2021 but negative from 1975–2021. Similarly, Emmanouilidis (2024) reports a short-term positive and long-term negative impact on the U.S. economy (1949–2021). Thus, no consensus exists on its economic implications.

Empirical research has yet to fully explore the medium- and long-term economic implications of defence spending. In the medium term, it may boost domestic demand but not trigger lasting capital or industrial growth. Additionally, in high-debt economies, it can crowd out public and private investment and distort resource allocation by influencing prices beyond market forces (Su et al. 2020). In this setting, most existing studies have neglected to examine both the medium- and long-term impacts of military spending, leading to an absence of conclusive proof. Recent studies have addressed this gap using advanced econometric methods, such as the ARDL model (Ajala and Laniran, 2021; Mohanty et al., 2020; Hung-Pin and Tsung-Li, 2022; Emmanouilidis, 2024).

For sure, an aspect that has yet to be examined is the probable variation in the effect of various categories of military budget on economic development. The absence of a disaggregated examination in existing empirical studies limits the interpretation of the connections between military expenditure and economic development, given that defence outlays encompass a diverse

range of expenditures. In particular, military outlays in every country consist of labour costs, military equipment, physical structures, and operating and maintenance costs for training and preparedness. It is reasonable to anticipate that these factors will have distinctive effects on economic growth.

According to Becker and Dunne (2023) the disaggregation of military budget presents an opportunity to explore new research questions on economic, military, and tactical resource division. Few studies (Bove & Cavatorta, 2012; Emmanouilidis, 2024; Olejnik, 2023; Becker & Dunne, 2023; Mohanty et al., 2020) have attempted to isolate its impact on economic development, yet their findings remain inconsistent due to variations in frameworks, models, estimation methods, and data. These limitations, along with country-specific military spending dynamics, prevent definitive policy recommendations. Given these contradictions and gaps, three critical research questions arise.:

- I. What is the effect of military expenditure on short- and long-term economic growth?
- II. What is the impact of each aspect of military expenditure on both long- and short-run economic growth?
- III. Is there a Granger-causal relationship between military expenditure and economic growth?

The primary objective of this empirical study is to contribute to the existing literature on the impact of disaggregated defence expenditure on economic growth, enhancing understanding of this relationship by exploring multiple dimensions.

First, the current body of evidence lacks consensus on the overall impact of defence spending on economic growth. Therefore, based on the most recent disaggregated data, our findings may have implications for developed economies like Greece, which have allocated substantial human and physical resources to defence over time and face potential socioeconomic and political challenges.

Second, rigorous econometric methods, such as the Johansen and Juselius (1990) cointegration test and ARDL technique, strengthen the conclusiveness of this study. The ARDL approach can identify both short- and long-term relationships, regardless of regressor integration (Pesaran et al., 2001). To ensure the robustness of our results, we also applied the DOLS estimation for long-run parameters (Mark and Sul, 2003), while VECM causality analysis tested for Granger causality. Additionally, impulse response functions (IRFs) were employed to capture dynamic causal effects beyond the current period.

Finally, this study aims to enhance the accuracy of its results by analyzing the relationships between distinct components of military spending and economic growth, while offering key policy recommendations. Greece serves as a case study, having consistently allocated over 2% of its GDP to defence for 44 years. This is particularly relevant for developed nations increasing defence budgets amid Russia's actions in Ukraine, as it helps optimize resource allocation for sustainable economic growth.

The article is arranged as follows: Section 2 offers a detailed overview of the military budgets in Greece and NATO countries. Sections 3 and 4 examine the existing theoretical and empirical literature's underpinnings in the field. Section 5 describes the model specification and data used in the study, while Section 6 presents the applied methodology. Section 7 reviews the empirical findings, while Section 8 concludes and offers policy recommendations.

## 2. Trends in the Defence Spending in Greece and NATO countries

Greece has consistently allocated significant resources to defence, ranking among North Atlantic Treaty Organization (NATO) and European Union (EU) nations with the highest militarization levels. This study compares Greece's military spending with major NATO members (U.S., U.K., France, Türkiye) and economically similar but strategically distinct countries (Spain, Portugal). Over the past 44 years, the U.S. and U.K. averaged 4.43% and 3.11% of GDP on defence, while Greece and Türkiye spent 3.43% and 2.99%, respectively. In contrast, France, Spain, and Portugal allocated 2.35%, 1.80%, and 1.60% of GDP to defence (see Figure 1).

In the aftermath of global crises from 2009 to 2019, military spending declined across economies. During this period, defence expenditure as a share of GDP stood at 3.98% in the U.S., 2.23% in the U.K., 2.60% in Greece, and 2.16% in Türkiye, while France, Spain, and Portugal allocated 1.90%, 1.29%, and 1.41%, respectively. However, since 2020, NATO members have gradually increased military spending, which accelerated further after Russia's invasion of Ukraine in 2022. Greece saw the most significant rise, with military spending reaching 3.07% in 2020, 3.87% in 2021, 4.02% in 2022, and 3.23% in 2023. This surge is linked to Türkiye's escalating Aegean tensions in 2020 and Greece's defence pact with France in 2021, leading to major purchases of French frigates and fighter jets.

Analysing the distribution of military outlays in Greece and NATO provides key insights into the drivers of high expenditure levels (see Figure 2). NATO categorizes defence spending into four types:

- a) *Equipment Outlays* – Includes both equipment procurement and R&D related to equipment.
- b) *Personnel Outlays*– Covers armed and civilian salaries, as well as retirement pensions.
- c) *Infrastructure Outlays*– Encompasses NATO's shared infrastructure and domestic military construction projects.
- d) *Other Outlays* – Covers operations, maintenance, additional R&D costs, and unclassified expenditures.

Greece allocates a significantly higher share of its defence outlays to personnel expenses than the NATO average. For the period 1980-2023, Greece spent 65.7% of its military budget on personnel, compared to NATO's 55%. Conversely, NATO nations allocate over 24.2% to operations, maintenance, and R&D, while Greece spends only 15.5%. Military spending in Greece surged in 2021–2023, focusing on equipment procurement. For the period 1980 to 2023, Greece and NATO allocated 17% of GDP to equipment, though Greece's spending fluctuated based on budgetary and political factors. Since 2020, military equipment spending has risen sharply due to

geopolitical tensions and force modernization needs. However, this increase was largely debt-financed, adding to Greece's already highest public debt-to-GDP ratio in the Eurozone, potentially straining fiscal stability and financial markets.

### **3. Theoretical literature on the relationship between defence spending and economic growth**

Governments allocate significant public funds to defence, yet their economic impact has only recently been analysed within economic theory. The literature centres on a debate between Keynesian and Neoclassical economic schools of thought, focusing on how defence spending affects economic growth.

Following the Keynesian paradigm, Dunne et al. (2005) argue that in situations where aggregate demand is insufficient, the national government demonstrates assertiveness and interventionism by implementing defence spending to trigger economic growth, employing multiplier effects. In this instance, military spending serves as a component of government expenditure that augments the overall demand in the economy, assuming that the provision of military goods and services to the government originates domestically. Based on the findings of Faini et al. (1984), it can be deduced that in an economy with a surplus of production capability, an increase in aggregate demand for a specific sector, such as defence spending, will trigger growth in the total national output. Additionally, there is expected to be an increase in capacity utilisation, prospective rates of profit, and investment due to enhanced profitability. As a result, the economy is anticipated to experience a sustained period of heightened growth.

In contrast, the neoclassical approach emphasises the importance of aggregate supply. Within the framework of the neoclassical theory, an augmentation in expenditures allocated to the military will ultimately result in a rise in public spending, thereby displacing private investment. Using tax revenues to augment military expenditures may result in a phenomenon called crowding out, displacing private investment. The anticipated outcome of the elevated tax rate is a decrease in savings, potentially resulting in an elevation of the national interest rate. The neoclassical perspective posits that military expenditure has a detrimental effect on economic growth. The approach mentioned above has been employed by numerous academics, as evidenced by the empirical investigations conducted by Murdoch et al. (1997), Aziz and Asadullah (2017), and Chang, Lee, and Chu (2015). Based on the concept of supply effects, it is postulated that several production elements, including human and physical capital, natural resources, and technology, may experience deviations from their optimal levels when military expenditure is increased. This deviation is believed to hurt economic growth, as Dunne et al. (2005) suggested.

### **4. A review of the empirical research on defence spending and economic growth**

Empirical literature suggests that defence spending can either promote or hinder economic growth. In developing nations, security concerns often justify its positive impact. Studies on Türkiye (Yıldırım et al., 2005), India and Pakistan (Tiwari & Shahbaz, 2013; Shahbaz et al., 2013), 124 developing economies (Yıldırım & Öcal, 2016), and 67 developing countries (Khalid & Noor, 2015) confirm its growth-enhancing effects. However, recent research highlights a negative correlation, as found in studies on Pakistan (Rehman et al., 2023; Lanrui et al., 2022; Luqman &

Antonakakis, 2021), the Middle East and Türkiye (Yolcu Karadam et al., 2017), South Africa (Phiri, 2019), Myanmar (Ahmed et al., 2020a), and Egypt (Maher & Zhao, 2022).

In advanced economies, excessive military spending on conflicts and political activities can act as negative externalities, hindering economic growth. Most empirical studies support this view, including research on the EU15 (Dunne & Nikolaidou, 2012), twelve Middle Eastern countries (Serkan et al., 2016), 70 developing nations (Aziz & Asadullah, 2017), NATO and EU countries (Becker & Dunne, 2023), and the USA (Emmanouilidis, 2024). Ahad and Dar (2017) further highlight a negative impact in the U.S. and U.K., but a positive effect in Russia.

Expanding military alliances, particularly NATO membership, has been linked to economic benefits. Callado-Muñoz et al. (2019) found that stronger military alliances enhance security and stability, supporting economic growth. Li et al. (2023) further demonstrated that NATO membership boosts trade, particularly increasing exports for new members.

In retrospect, mostly panel studies in developed economies (Bove & Cavatorta, 2012; Becker & Malesky, 2017; Dunne & Smith, 2020; Kollias & Tzeremes, 2022; Becker & Dunne, 2023) examined the economic impact of military expenditure, but policy recommendations are limited due to the country-specific nature of military spending's effects. In addition, recent research focused on developed single-country economies, such as studies on Spain (Dimitraki & Emmanouilidis, 2023) and the United States (Emmanouilidis, 2024), shows no consensus on the economic implications of defence spending.

Most significant, few studies have effectively isolated the economic implications of military spending but there are concerns with their findings due to issues with data reliability, econometric methodology, and result robustness. For example, Malizard (2013) analysed France's military spending (1980–2010), finding that non-equipment spending crowds out investment, while equipment spending boosts it. Similarly, Mohanty et al. (2020) studied India's defence spending (1970–2016), concluding that capital defence investment supports growth, while revenue expenditure does not. Emmanouilidis (2024) analysed the U.S. (1949–2021) using ARDL but found weak estimates and inconsistent results for explanatory variables. Finally, Becker and Dunne (2023) studied NATO and EU countries (1970–2016), with only one model yielding robust results for military personnel spending.

The empirical literature on Greece's defence outlays and economic growth is extensive but yields conflicting results, mirroring global studies on the topic. Several key insights emerge:

First, prior studies on Greece show mixed conclusions. For instance, some studies (see Dunne & Nikolaidou, 2001; Antonakis, 1997, 1999) suggest a negative impact, while others (see Kollias, 1995; Balfoussias & Stavrinou, 1996) indicate a positive effect. Several studies (Nikolaidou, 2016; Manamperi, 2016; Georgantopoulos, 2012; Dunne & Nikolaidou, 2005; Dritsakos, 2004; Dunne et al., 2001; Chletsos & Kollias, 1995; Kollias & Makrydakos, 2000) find no significant relationship.

Second, many econometric studies use panel data, grouping Greece with countries that differ in economic conditions and security threats. While insightful, these studies do not provide clear policy guidance, as the impact of defence spending varies with economic development, military expenditure levels, and budget allocation (Dunne & Nikolaidou, 2012; Kollias & Paleologou, 2016; Malizard, 2016). Third, most prior studies, except for Paparas et al. (2016), Nikolaidou (2016), and Manamperi (2016) and have not incorporated post-crisis data. This study addresses that gap by utilizing the latest available dataset.

Finally, many studies rely on ordinary least squares (OLS) regression, which may produce spurious results due to non-stationary time-series data. Establishing cointegration is crucial, as highlighted in studies like Chletsos & Kollias (1995), Antonakis (1997), and Nikolaidou (2016), and Dunne & Nikolaidou (2001).

Table 1 provides a comprehensive overview of empirical research on Greece's defence spending and economic growth.

**Table 1. A selected list of Empirical Studies focused on the case of Greece.**

The examination of the literature underlines the substantial research analysing the economic implications of military outlays. Nonetheless, the results remain unclear. The inconsistencies arise from differences in theoretical models, applied variables, econometric methods, forms of data, the sample examined, and the time sample of studies. There is a notable deficiency in extensive research that simultaneously investigates the compositional impacts of military outlays on economic expansion.

This research aims to mitigate these limitations by using the most recent classified defence expenditure data to offer substantial and comprehensive analyses for policy formulation. To address this, we tested three null hypotheses:

H<sub>01</sub>: Military expenditure exerts an identical effect on short- and long-run economic growth.

H<sub>02</sub>: Different categories of military expenditure do not have distinct effects on economic growth.

H<sub>03</sub>: There is no Granger causal relationship between military expenditure and economic growth.

## 5. Model Specification and Data

The Barro simple growth paradigm (1990) has been widely utilized in military economics to examine the relationship between defence spending and economic growth. According to Barro's framework, government expenditures—funded by taxes—can influence output through their effects on the production function (Yakovlev, 2007).

However, due to the complexity of the original model, economists have had to account for exogenous variables when analysing the link between military expenditures and economic performance (Aizenman & Glick, 2003). To ensure a comprehensive and methodologically sound investigation, this study employs a modified version of Barro's model, as seen in prior research (Mylonidis, 2008; Pieroni, 2009; Manamperi, 2016). This adaptation allows for a more robust assessment of how defence spending affects economic growth by incorporating key macroeconomic variables and country-specific factors.

Thus, in equation (1), we estimate the following regression model for Greece from 1980 to 2023.

$$GDPpc_t = \alpha_1 + INVE_t + EDUC_t + POPU_t + \sum_{j=1}^5 \varepsilon_j MILIT_{jt} + u_{1,t} \quad (1)$$

GDP  $pc_t$  signifies the log of income per capita (constant 2015 US\$) at time  $t = 1, 2, \dots, T$ ; INVE $_t$  signifies the gross fixed capital formation as a % of the GDP; EDUC $_t$  indicates the attainment rate of upper secondary education, and POPU $_t$  is the population growth. The variable  $\alpha_1$  represents a continuous parameter, while  $u_{1t}$  denotes a residual term that follows a normal distribution. Finally, MILIT $_{jt}$  for  $j=1, \dots, 5$ , corresponds to various metrics of military spending, i.e. the log of total military outlays (constant 2015 US\$), the log of military outlays related to equipment (constant 2015 US\$), the log in military outlays devoted to personnel (constant 2015 US\$), the log of military outlays linked to personnel (constant 2015 US\$) and the log of military outlays linked to operating costs (constant 2015 US\$), respectively.

The current study utilizes a unique dataset of annual observations for Greece from 1980 to 2023 to provide more robust and insightful results. The data about the GDP per capita, gross, investment, and population was obtained from the World Bank (2024). Data about the levels of upper secondary education has been gathered from UNESCO (2024). The data about the defence expenditures, measured retrieved from the Stockholm International Peace Research Institute (SIPRI, 2024) records.

Data on Greece's primary defence expenditure categories were collected through a meticulous analysis of various documents, predominantly typewritten and subsequently scanned, entitled "Information on Defence Expenditures," released by NATO (2024). The research concentrated on Greece due to practical considerations. The documentation of the "distribution of total defence expenditures by category" was first introduced by NATO through the utilisation of average numbers spanning the periods of 1970-1974, 1975-1979 (only for the equipment subcategory) and 1980-1984 (for all the four subcategories of defence outlays). Following this, in 1985, NATO initiated documenting distinct annual data. The previously listed categories included various elements such as equipment, personnel, infrastructure, and additional expenses related to operations. The dataset for 1980-1984 is commonly considered as an annual average for 1980. The interpolation method allows for estimating the absent data points from 1981, 1982, 1983, and 1984, as described in previous empirical studies (see, for example, Teixeira and Loureiro, 2019; and Becker and Dunne, 2023). However, interpolating missing data has a drawback as it fails to identify local extremes between reference locations, affecting sample size, sampling rate, and measured data's volatility (De Waal et al. 2019).

However, there remains some debate, albeit reduced compared to the past, regarding the accuracy of the NATO data utilised in the study. Data discrepancies are primarily influenced by two or three countries, with Greece being the most significant, exhibiting the largest differences between NATO and SIPRI data from 1980 to 2000 (see, Becker, Lute and Webster 2024). Importantly, single-country investigations exhibit constraints stemming from factors such as a nation's size, historical origins, political regime, economic structure, and geopolitical location, which may result in significant variations in the compositional and economic impacts of military outlays on economic growth. The recent availability of reliable data for military outlays data across a larger set of countries suggests the potential to expand the number of cases in future studies (see Becker et al. 2024).

To conduct a thorough analysis, we generated four additional variables to denote the four distinct categories of defence spending. These variables were measured in millions (in logs), denominated in 2015 US dollars. They were derived by multiplying the relative percentages obtained from the distribution of total defence expenditures by category within NATO to the

defence expenditures. Table 2 provides inclusive information regarding the variables and dataset employed in this empirical investigation.

**Table 2. Information about the variables and dataset**

## **6. Methodology**

This study used various econometric and statistical tests to study the relationship between military expenditure and GDP in Greece. The necessity and rationale for these tests are outlined as follows: The initial step involved assessing the stationarity of each time series. Three unit-root tests were employed to assess the stationarity of the time series data. Besides the ARDL methodology we also applied the Johansen and Juselius (1990) cointegration method. To ensure the robustness of our results, we also applied the DOLS estimation for long-run parameters (see Mark and Sul, 2003), while VECM causality analysis tested for Granger causality. Additionally, impulse response functions (IRFs) were employed to capture dynamic causal effects beyond the current period.

Furthermore, to guarantee the accuracy of the research, we utilised various diagnostic assessments, including the Jarque-Bera normality test, the heteroscedasticity test (BPG test), the serial correlation test (LM test), and stability modelling evaluations.

This study employed detailed data on Greece's primary defence expenditure categories. Missing data are common, but must be resolved to ensure accurate conclusions or to enhance datasets that inform the principal defence expenditure categories, and were collected from "Information on Defence Expenditures," issued by the NATO database. Interpolated data can be helpful in filling gaps in empirical research, but it also has several drawbacks. It can provide less accurate estimates due to the absence of actual observations, introduce bias due to the choice of interpolation method, underestimate variability due to smoothing out changes, and affect statistical inference by causing biased standard errors, p-values, and confidence intervals. It can also lead to a loss of information due to the inability to completely recover information from real observations. Additionally, interpolation can amplify or exacerbate issues caused by outliers or measurement errors (see Gujarati & Porter, 2009; and Wooldridge, 2016). It is essential to explicitly indicate that interpolated data were utilised just for the years 1981, 1982, 1983, and 1984, while our sample encompasses the period from 1980 to 2023.

### **6.1 Unit Root Analysis**

In the initial phase, we evaluated the integration characteristics of the variables by analysing the existence of unit roots in all the used variables. We employed sophisticated unit root checks, including the DF-GLS (Elliott et al. 1996) and NP (Ng and Perron 2001), however these checks fail to consider breakpoints within the time series. To remedy this deficiency, we utilised the Zivot and Andrews (2002) check to ascertain a singular undetermined turning point inside the time series. All the unit root examinations were conducted by using both a constant and a constant with trend.

## 6.2 Cointegration Analysis

The present research uses two cointegration methods: the Johansen and Juselius (1990) technique, and the ARDL technique to examine the long-term relationship between defence outlays and economic growth in Greece.

First, the Johansen and Juselius (1990) cointegration method was employed to examine the existence of long-term relationships among the variables of interest. This assessment is based on  $m_{\text{trace}}$  and  $m_{\text{max}}$  indications. The  $m_{\text{trace}}$  cointegration rank 'r' is as follows:

$$\lambda_{\text{trace}} = -T \sum_{j=r+1}^n \ln(1 - \lambda_{\text{trace}})$$

Secondly, the maximum number of cointegrating vectors, defined as 'max test', is represented as  $r+1$  as follows:

$$\lambda_{\text{max}}(r, r+1) = -T \ln(1 - \lambda_j)$$

The JJ cointegration test posits a null conjecture asserting the absence of a long-term relationship among the variables. If the values of ( $m_{\text{trace}}$  and  $m_{\text{max}}$ ) exceed the critical value, the null conjecture, which posits the absence of a significant long-run link among the variable series, is rejected. Importantly, this method requires the employed variables to be integrated of the identical order, typically I(1).

Additionally, we used the more robust technique of ARDL introduced by Pesaran et al. (2001) and include a multivariate structure that assesses all the relative variables in the empirical specification of equation (1). In fact, the ARDL methodology demonstrates substantial enhancements compared to traditional cointegration techniques, such as those established by Johansen and Juselius (1990). The ARDL technique: (a) examines the occurrence of long-run relationships, regardless of the order of integration; (b) is considered more reliable, especially for insufficiently long time series data sets; (c) the issue of endogeneity can be efficiently mitigated; and (d) the estimates of the short-run and long-run independent variables are consistent because they are assessed concurrently with a modest change (Pesaran et al. 2001).

Nonetheless, there are certain limitations to consider. The ARDL bounds testing proposed by Pesaran et al. (2001) is applicable solely for orders of integration not exceeding 1, specifically between I(0) and I(1) inclusive. In cases where the time series exhibits higher order integration, such as I(2), the results become invalid. Initially, unit root tests are conducted, although not strictly necessary for ARDL, to determine the appropriateness of this method. Furthermore, results may be inconclusive if the test statistics fall within the two critical value bounds, necessitating the use of alternative testing methods.

In the setting of cointegration analysis employing the ARDL methodology, the initial phase entails a comprehensive examination of long-term dynamics applying an augmented ARDL model, which adapts the empirical paradigm (1) denoted by equation (2).

$$(2)\Delta GDPpc_t = \alpha_1 + \sum_{i=1}^n \alpha_{2,i} \Delta GDPpc_{t-i} + \sum_{i=0}^n \alpha_{3,i} \Delta INVE_{t-i} + \sum_{i=0}^n \alpha_{4,i} \Delta EDUC_{t-i} + \sum_{i=0}^n \alpha_{5,i} \Delta POPU_{t-i} + \sum_{j=1}^6 \sum_{i=0}^n \alpha_{6,j,i} \Delta MILIT_{j,t-i} + \beta_1 GDPpc_{t-1} + \beta_2 INVE_{t-1} + \beta_3 EDUC_{t-1} + \beta_4 POPU_{t-1} + \sum_{j=1}^5 \beta_{5,j} MILIT_{j,t-1} + u_{2,t}$$

The symbolisation  $\Delta$  is typically employed to denote the first difference of each variable. The variable  $GDPpc_t$  denotes the GDP per capita.  $INVE_t$  refers to domestic investment,  $EDUC_t$  indicates the secondary education attainment,  $POPU_t$  represents the population growth rate, and  $MILIT_t$  represents the various metrics of military expenditure.

The F-statistic was applied to estimate the long-term correlation between the variables by utilising the statistical importance of the lagged degrees of the regressors. Following Pesaran et al. (2001), the null assumption is defined as the lack of a long-run co-integration connection among the variables in equation (2).  $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_{5,1} = \beta_{5,2} = \beta_{5,3} = \beta_{5,4} = \beta_{5,5} = 0$  as opposed to the alternative hypothesis.  $H_a: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_{5,1} \neq \beta_{5,2} \neq \beta_{5,3} \neq \beta_{5,4} \neq \beta_{5,5} \neq 0$ .

The F-statistic is evaluated using Pesaran et al. (2001) critical statistics and the F non-standard test distribution. Pesaran et al. (2001) define two key thresholds: a lower and an upper bound. The smaller critical value assumes all independent variables are stationary at level I(0), while the higher critical value assumes all variables are stationary at first difference I(1).

If the calculated F-statistic surpasses the upper critical boundary, the null conjecture of no cointegration is declined; otherwise, it is accepted. If the F-statistic falls between the lower and upper bounds, the result is inconclusive. To confirm a long-term relationship, cointegration must be verified. By incorporating the  $ECT_{t-1}$  into the ARDL model, the methodology captures the speed of adjustment, where a negative sign confirms convergence from short to long term and a causal link between variables. The difference operator ( $\Delta$ ) represents variable changes, with lag values selected using the Akaike Information Criterion. Finally, in Error Correction Model equation (3), the residual term and constant parameter have a normal distribution.

$$\Delta GDPpc_t = \theta_1 + \varphi_1 ECT_{t-1} + \sum_{i=1}^k h_i \Delta GDPpc_{t-i} + \sum_{i=0}^n k_i \Delta INVE_{t-i} + \sum_{i=0}^n l_i \Delta EDUC_{t-i} + \sum_{i=0}^n m_i \Delta POPU_{t-i} + \sum_{j=1}^5 \sum_{i=0}^n n_{j,i} \Delta MILIT_{j,t-i} + u_{3,t} \quad (3)$$

### 6.3 Estimation of Long Run parameters

The ARDL methodology calculates<sup>1</sup> the long-term influence of independent regressors on the dependent variable using [eq 2] (Bardsen, 1989):

$$\hat{\gamma}_i = -\frac{\hat{\beta}_i}{\hat{\beta}_1} \quad (4)$$

<sup>1</sup> The long-run coefficients are calculated automatically via the use of EViews 14.

Where  $\hat{\beta}_i$  and  $\hat{\beta}_1$  are the computed long-term parameters in Equation [2]. The  $\hat{\gamma}_i$  s indicates how the dependent variable, the log of the GDP per capita, replies in the long term to any adjustment in the independent variables, i.e., the domestic investment; the attainment rate of secondary education ; the population growth; and the various metrics of military spending.

To ensure robust results on the long-term economic effects of military spending, we employ the Dynamic Ordinary Least Squares (DOLS) method (Mark and Sul, 2003), which performs well with small datasets and reduces bias from endogeneity and serial correlation (Kao & Chiang, 2000).

#### 6.4 The VECM Granger Causality Analysis

In case the Johansen and Juselius (1990) cointegration test indicate a cointegrated relationship among the variables, we will proceed to the vector error correction model (VECM). The VECM technique demonstrates short-term dynamics through the statistical significance of the Wald Test and establishes the long-term connection between parameters through the utilisation of a statistically competent ECT. The enhanced version of the Granger causality method is defined within a multivariate pth order vector error model, as outlined below:

$$\begin{bmatrix} \Delta(GDPpc_t) \\ \Delta(INVE_t) \\ \Delta(EDUC_t) \\ \Delta(POPUL_t) \\ \Delta(MILIT_t) \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix} + \sum_{i=1}^{k-1} \begin{bmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} & \beta_{14i} & \beta_{15i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} & \beta_{25i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} & \beta_{35i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} & \beta_{45i} \\ \beta_{51i} & \beta_{52i} & \beta_{53i} & \beta_{54i} & \beta_{55i} \end{bmatrix} \begin{bmatrix} \Delta(GDPpc_{t-k}) \\ \Delta(INVE_{t-k}) \\ \Delta(EDUC_{t-k}) \\ \Delta(POPUL_{t-k}) \\ \Delta(MILIT_{t-k}) \end{bmatrix} + \begin{bmatrix} \psi_1 \\ \psi_2 \\ \psi_3 \\ \psi_4 \\ \psi_5 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \\ u_{5t} \end{bmatrix}$$

#### 6.5 Impulse Response Analysis

The impulse response analysis demonstrates the response of an endogenous variable to innovations or shocks from other variables. The analysis assesses the current and future reactions of an endogenous variable following a one standard deviation shock. Notably the impulse response function It is primarily used for evaluating causal analysis and assessing the effectiveness of policies.

## 7 Findings

### 7.1 Summary Statistics

Table 3 presents descriptive statistics associated with each of the used variables. Based on the values of skewness and kurtosis, it can be concluded that all variables used satisfy the conditions for normality, with kurtosis and skewness metrics required to be  $-3$  and  $+3$ , and  $-1$  and  $1$ , correspondingly. In addition, the Jarque–Bera (JB) normality test was utilised to assess skewness and kurtosis in relation to the normal distribution of data. The JB test indicates that all variables were normally distributed, as the rejection probability value exceeded  $0.10$ . Most significant,

Jarque-Bera distribution normality test beyond skewness and kurtosis. It uses skewness, kurtosis, degree of freedom, and the regression coefficients (Thadewald, & Büning, 2007)

### **Table 3. Summary statistics of the variables**

We utilised the variance inflation factor (VIF) to evaluate multicollinearity across all five model specifications. According to Hosmer and Lemeshow (2013), VIF values greater than 10 are generally regarded as indicative of multicollinearity and require additional examination. Table 4 illustrates the lack of a significant linear correlation among the regressors.

### **Table 4. Results of VIF test**

#### **7.2 Findings for the unit root tests**

Table 5 displays the findings of the DF-GLS (Elliott et al. 1996) and NP (Ng and Perron 2001) unit root tests, indicating that nearly all variables demonstrated stationarity following first-order differentiation. The results of the Zivot and Andrews (2002) unit root test that is testing the presence of structural break are also presented in Table 5 indicate that all variables achieved stationarity at the first difference. The economic crisis in Greece clearly caused significant structural breaks during the period from 2008 to 2016. Given that none of the series achieved stationarity at or beyond the first difference level, we can proceed with the implementation of two cointegration tests: a) the Johansen and Juselius (1990) and b) the ARDL methodology (Pesaran et al. 2001).

### **Table 5. Results of the unit root tests**

#### **7.3 Findings for the cointegration tests**

In testing cointegration relationships, it is essential to determine the inclusion of deterministic components, such as constants, time trends, and dummy variables, in the model. A specific model is selected for each model specification, incorporating subsequently as explanatory variables the total military spending and various categories of military spending, following a general-to-specific approach. The criterion for selecting lag length involves the use of the Akaike (1974) Information Criterion (AIC) and Schwarz (1978) Bayesian Information Criterion (SBIC) alongside diagnostic tests. The chosen lag length must allow residuals to successfully meet several diagnostic tests, such as those for heteroskedasticity, serial correlation, normality and functional form. The AIC, recognised for its exceptional power characteristics in small sample sizes compared to other lag selection criteria (Lütkepohl 2006), is employed to ascertain the lag length. The AIC yields consistent results concerning final prediction error (FPE) and sequential modified LR test statistic. The recommended optimal lag selection is four (see Table 6).

### **Table 6. Lag selection criteria**

This study employed the Johansen and Juselius (1990) multivariate cointegration technique to analyse the long run relationships among the variables and the findings are illustrated in Table 7. Both maximal eigenvalue and trace statistics and statistics imply the presence of four cointegration vectors, confirming a long-term relationship among the variables.

### **Table 7. Johansen and Juselius (1990) cointegration test results**

Additionally, we applied the ARDL cointegration analysis. Table 8 shows the ARDL cointegration analysis results for equation (2). In all model specifications, the tests exhibit statistical significance, thereby rejecting the null conjecture that there is no cointegration and establishing the presence of a long-term connection among the variables.

### **Table 8. The ARDL cointegration test results**

#### **7.4 Findings for the short and long-run estimated coefficients**

Having established a long-term relationship, we estimated the short and long-run influences of defence spending (and its subcategories), investment, education, and population on GDP per capita (see Table 9).

### **Table 9. The short and long-run estimated coefficients**

Based on the estimated short-run coefficients, it can be deduced that a positive relationship exists between military expenditure and per capita income in the short term. This association is statistically vital at the 1% level.

There are two approaches to connect the existed theoretical and empirical literature with the short-term beneficial economic effects of Greece's defence expenditures. First, we can stress the Keynesian multiplier impact, which postulates that an escalation in military outlays generates a boost in the demand for products and services, subsequently reducing resource redundancy. This is a potential indication of a positive impact of military expenditure on economic growth (Pieroni et al. 2008), In the Greek context, the immediate beneficial influence of military expenditure on economic growth stems from the demand-stimulating effects arising from the wages provided to civilians and military workforce in the defence sector. The augmentation in aggregate demand within the economy results in a ensuing rise in levels of output and employment.

Second, the beneficial impact of military spending on growth in the medium term is consistent with the empirical findings of Khalid and Habimana (2021) for Türkiye, Ahmed et al. (2020a) in Myanmar, Emmanouilidis (2024) for the United States and Dimitraki and Emmanouilidis (2023) for Spain, that indicate that military expenditures favour economic growth in the short run.

In addition, this outcome is not surprising regarding the allocation of defence spending, as depicted in Figure 2. Greece prioritises personnel expenditures, encompassing civilian and military domains of public expenditure. Greece exhibits a diachronic pattern of elevated unemployment rates, with an average of 12.08% for the period spanning from 1980 to 2023. Notably, it has consistently recorded one of the highest youth unemployment rates within the European Union, reaching 33.22% (World Bank, 2023). Greek governments have pursued a strategy of extensive military sector recruiting, primarily driven by political motivations, to address the issue of high unemployment rates.

Concerning the effect of the investment variable on economic growth, it can be affirmed that a relatively positive association exists between economic development in the short term. This finding suggests that the contribution of domestic investment to the economic output has a relative immediate effect on economic growth. Similarly, following an analysis of the cumulative elasticities for lagged variables about variations in educational attainment and demographic expansion in the short term, it may be inferred that a delayed beneficial impact of rising population and education levels on economic growth exists.

The lagged ECT has a negative value and is statistically important at the 1% level across all model settings. ECT measures how quickly cointegrated parameters return to equilibrium after a disturbance or change in connection. The ECT exhibits a value of -0.418, indicating that approximately 41.8% of the discrepancy is rectified yearly.

Table 9 also presents the analysis of the long-term coefficients (both ARDL and DOLS estimators). All long-run indicators are statistically significant, affecting economic growth over time. The long-term coefficients are substantially larger than the short-term estimations, showing that the variables have a bigger long-term impact.

Our research clearly confirms that long-term military expenditure hurts economic growth. This finding is statistically robust at a 1% significance level in all model specifications. *Ceteris paribus*, a rise of 1% in military spending results in a reduction in per capita income 0.157%. Accordingly, this analysis indicates that military spending has a destabilising effect in the case of Greece, and a rise in military expenditure can hinder economic growth in the long term. The results of our study agree with the studies conducted by Antonakis (1997; 1999), Paparas et al. (2016), and Dunne and Nikolaidou (2001), which demonstrate a negative impact of military expenditure on economic growth in the context of Greece.

In retrospect the findings show that while military spending may have positive effects on short-term economic growth, it negatively impacts long-term growth. This discrepancy can be explained by both the existed theoretical and empirical literature.

First, according to theoretical literature, higher defence expenditures can enhance domestic consumption in a brief period, a phenomenon referred to as the Keynesian multiplier effect. Nonetheless, these transient stimulating impacts do not inherently improve production or capital capacity. Increased military expenditure over time possibly diminishes the production capacity

via two mechanisms. The initial mechanism highlights the negative impact of military expenditure on both private and public investment for other sectors of an economy, evidenced by a crowding-out effect. This negative impact is notably pronounced in heavily indebted countries with restricted access to international financial markets, prompting government officials to utilise taxation as an alternative source to enhance public revenues. The second mechanism pertains to the immediate impact of military outlays on the efficiency of rational allocation of resources, which may diminish the effective use of capital goods and labour productivity. Yet, consider the case that market forces typically do not control military expenditure, leading to potential disruptions in relative prices (Elveren and Hsu 2016; Carter et al. 2021).

Second, this discrepancy is in accordance with other studies such as Khalid and Habimana (2021) for Türkiye, Ahmed et al. (2020a) in Myanmar, Emmanouilidis (2024) for the United States, and Dimitraki and Emmanouilidis (2023) for Spain.

In Greece, defence spending appears unproductive in the long term for several reasons. First, over the past four decades, excessive military spending has limited the budget for other public expenditures, with Greece consistently ranking low in EU public spending on health, education, and social services. Second, military spending incurs significant opportunity costs, diverting resources from civilian uses. Third, it also discourages domestic investment in other sectors, as the benefits from armaments programs have not sufficiently supported the local defence industry. Finally, the country's disproportionate military expenditure (see Figure 2), coupled with economic crises, austerity, political instability, and poor performance in tackling corruption and ensuring sound governance (see, Corruption Perception Index and World Governance Indicators, 2024), further exacerbate the negative effects of high defence spending.

Furthermore, there is a strong statistically significant link between domestic investment and economic growth in Greece, with results reaching a 1% significance level. This suggests that government support for investment, through grants and tax allowances, can drive long-term growth. *Ceteris paribus*, a 1% rise in gross fixed capital formation results in a 0.040% growth in GDP per capita. According to the neoclassical perspective, while domestic investment has a moderate beneficial effect on growth, increased military spending can displace private sector investment. Military spending funded by higher taxes reduces savings, leading to higher interest rates and weakening overall economic growth.

Concerning the influence of higher education and population growth on economic growth, both factors demonstrate a statistically significant impact. Specifically, our study reveals that population growth and college education level contribute to the increase in GDP per capita of 0.321% and 0.044 %, respectively. The findings of this study align with prior research conducted by Tsitouras et al. (2017) in European transition economies, Islam (2017) in Japan and Tsitouras et al. (2020) in Greece.

Importantly, the results for the long parameters from the DOLS estimation are identical to those retrieved from the ARDL methodology, ensuring that our results are consistent across various analytical methods (see Table 9).

The findings of the disintegrated examination of military expenditures are presented in Table 10. There are four primary categories of military expenditures: 1) equipment, 2) personnel, 3) infrastructure, and 4) operational costs. It is evident from the relative findings that all subcategories (except military operating costs) have nourished to the economy's growth in the medium term.

Intriguingly, our findings indicate that military expenditure on personnel has the most significant impact on economic development, as shown by the relative size of the coefficient of military expenditures in personnel compared to other categories of military spending. This is a compelling finding. Specifically, in Greece, the defence industry offers higher wages to its personnel than the private sector. This phenomenon causes an upsurge in overall demand, which subsequently causes a significant rise in the employment rate. The logic suggests that underclass groups whose members enter the military will enjoy a higher standard of living due to a more equitable revenue distribution.

**Table 10. The short and long-run estimated coefficients (disaggregated analysis)**

Table 10 also provides the results relating to the disintegrated effect of military outlays on economic growth in the long term. The empirical evidence implies that each subcategory of military expenditure has a detrimental effect on long-term economic growth. The findings indicate that, *ceteris paribus*, 1% increase in military spending allocated to personnel leads to a decrease in economic development of 0.297%. Similarly, *ceteris paribus*, a 1% rise in military expenditure allocated to equipment, infrastructure, and operating costs leads to a reduction in GDP growth of 0.047%, 0.064%, and 0.066%, respectively.

From the comparison of the magnitude of the coefficients of the four subcategories of the military budget, it is evident that military spending on personnel has the most detrimental effect on economic growth in the long run. The present finding is of critical significance. Naturally, this result justifies those armed forces as a percentage of total labour in Greece, which accounts for 3.59%. In contrast, the same indicator is valid for the rest of NATO countries, which account for 1.43% (World Bank, 2023). This indicates that the military expenditures allocated to personnel in Greece exert a more significant negative effect on the economy in the long run, owing to more substantial opportunity costs. This stems from the fact that Greek military personnel have exclusive access to more and better social and health provisions and assets (military hospitals, military doctors, early retirement, and more excellent pension funding systems) than the rest of the indigenous population, not to mention, the Greek military spending on personnel is diachronically inflated with military pensions (see Economist 2024).

Considering the negative impact of military expenditures on equipment on economic growth, we can stress the following factors. Historically, Greece has relied primarily on imports of armaments rather than on developing a robust domestic defence industry. In the case of Greece, even the issue of compensatory liabilities from previous years for arms imports in recent years appears to be fading. This hurts the progress of the domestic defence industry as a whole, but more specifically, the research and development expenditures within these sectors and the dissemination of expertise to other sectors of the economy.

The results also indicate that Greece's military expenditures focused on infrastructure hurt economic growth. We can stress that this expense has the smallest share of Greece's military budget and focuses on projects that cannot be used in the civilian sector. The Mixed Reconstruction Machinery Teams (MRMT) was a Greek military organisation of a construction nature that was active from 1957 to 1992. The organisation's primary purpose was to reconstruct the country's infrastructure (bridges, airports, roads, etc.) subsequent to the tremendous devastation inflicted by the Second World War and the Greek Civil War

The MRMTs were abolished in 1992, but in 2015 a similar service was established in the Research and Construction Unit. Given the effects of climate change and the subsequent natural disasters in Greece in recent years, the military's involvement in public infrastructure and contingency plans has become more crucial in provisional and repressive capacities. This, in turn, could mitigate the negative impact of military spending on economic growth in the long run.

Moving our focus towards the adverse implications of operations and maintenance expenditures and supplementary research and development costs, it is noteworthy that such expenditures have consistently declined from 1980 to 2023 in Greece. Specifically, the proportion of these expenditures within the Greek military budget has decreased from 25% in 1980 to 13% in 2023. Aside from the evident economic costs, this military expenditure can yield significant financial advantages. Importantly, Heo (2010) argues that a strong military can guarantee national security and generate additional benefits through its operations and maintenance (O&M) programmes. These activities can enhance human capital, potentially providing advantages in the post-military labour market (Gonzalez & Simpson, (2021).

Importantly, the results for the long parameters of the disintegrated examination of military expenditures from the DOLS estimation are equal to those retrieved from the ARDL methodology, confirming that our results are consistent across various analytical methods (see Table 10).

### **7.5 Findings of the diagnostic tests of ARDL specifications**

Table 11 indicates that each ARDL model specification surpasses the diagnostic tests, as the rejection probability value exceeded 0.10 for heteroskedasticity, serial correlation, normality, and functional form, thereby supporting the validity of all the examined models. In addition, the time series data between 1980 and 2023 may include gaps due to structural changes brought on by the evolution of the Greek economy. To this end, we employed the CUSUM and CUSUMSQ tests and the results demonstrate statistical importance at the 5% level. Thus, the estimated coefficients both in the short-run and long-run exhibit minimal variation within the specified intervals (see Figures 3a-f).

**Table 11. Diagnostic tests for ARDL models**

### **7.6 Findings of cumulative dynamic multipliers**

Each graph and response curve demonstrates convergence to equilibrium in the long-term values. The lines in Figures 4a-h signify long-run coefficients from Tables 10 and 11. Figure 4a depicts that a 1% positive shock to domestic investment leads to a constant GDP increase over five years, reaching a 0.04% gain in six years.

Figure 4b illustrates that a 1% increase in secondary education attainment initially reduces GDP by 0.022% over three years. However, its positive impact grows steadily from years 4 to 7,

surpassing 0.04% after year 8. Similarly, Figure 4c shows that a 1% population expansion results in a 0.30% GDP gain over eight years, following a gradual medium-term rise subsequent to the initial three years.

Figure 4d illustrates that a 1% rise in military expenditure initially boosts GDP by 0.04% within the first two years. However, from years 3 to 7, this effect reverses, leading to a gradual adverse impact on economic growth. Beyond year 8, the adverse effects of military expenditure stabilize at approximately -0.16% for each 1% positive shock.

Figures 4(e, f, g, and h) illustrate the effect of distinct categories of armed expenditure on economic growth. Initially, military equipment, personnel, and infrastructure expenditures positively affect GDP. However, their effects turn negative after approximately 1.5 years for equipment, 2 years for personnel, and 3 years for infrastructure. In contrast, other military expenses consistently exert a destructive impact on economic growth for each 1% positive shock.

### 7.8 Findings of the Vector Error Correction Model (VECM) Granger Causality Analysis

The VECM requires determining the optimal lag order before estimation. The VEC Lag Exclusion Wald Tests indicate that four lags constitute the best lag structure. With this optimal lag selection, we proceed to choose an appropriate cointegration model that includes a constant. Since the variables exhibit cointegration, causality can be analyzed in terms of both long-term and short-term relationships. The findings of the VECM Granger causality test are provided in Table 12<sup>2</sup>.

The coefficient of the lagged error correction factor in the GDP per capita equation is statistically significant at the 1% level and has the appropriate negative value. The ECT coefficient in the GDPpc equation is -0.186, indicating 18.6% yearly short-term to long-term adjustments. In the GDPpc equation, long-term Granger causality runs from investment, military spending, education, and population.

Conversely, the investment variable is not a significant determinant of economic growth in the short run the case of Greece. A series of evidence clarify the absence of a casual impact of domestic capital formation on economic expansion. First, increased military expenditure can enhance total government expenditure; however, it may also crowd out domestic investment for other sectors of the economy such health, education etc. Second, increased taxation or debt for military funding may displace private financing and investment by diminishing deposits and elevating national interest rates respectively. Third, Greece's diachronically gross fixed capital formation levels have been low, averaging 20.09% of GDP from 1980 to 2023, but declining to 13.58% since 2008, which has led to restricted growth. Fourth, Greece emphasised current expenditure at the expense of investment projects and has encountered issues of corruption and poor governance, which have negatively impacted the efficacy of public investment. Finally, we observe in the investment equation that military spending appears to be significant determinant of domestic investment, both in the short and long run, which the direct relationship between these two factors.

<sup>2</sup> We tested different types of military spending in the VECM and Impulse responses analysis, but the total military expenditure results were similar. These results were omitted to save manuscript space.

Overall, the estimates from the causality analysis indicate that in the long-run, there is a bidirectional causality between economic growth and investment, economic growth and education, economic growth and military spending, investment and education, and military spending and education.

These bidirectional relationships imply that while one variable influences the other, the reverse is also true. For example, economic growth stimulates military spending, but at the same time, military spending exerts a significant influence on GDP, which can be detrimental if excessive.

This has critical implications for Greek policymakers. Military spending decisions should be made with a broader perspective on sustainable economic growth rather than being solely dictated by long-standing security concerns, particularly regarding Türkiye. The geopolitical tensions in the Aegean Sea have historically driven Greece to allocate a significant portion of its budget to defence, often without regard for economic constraints.

Given Greece's experience with a decade-long debt crisis, uncontrolled military expenditures could reintroduce fiscal instability. A surge in defence spending without corresponding economic benefits could lead to renewed pressure from financial markets and international institutions. Therefore, Greece must balance its security needs with economic sustainability, ensuring that military expenditures do not compromise long-term fiscal stability and growth.

Regarding the short-run Granger causality relationships there is evidence of a uni-directional causality running from military spending to economic growth and not the opposite. In addition, it is evident a feedback relationship between investment and military spending and two unidirectional relationships running from population and education to military spending.

### **Table 12. The results of the VECM granger causality test**

#### **7.9. Findings of the impulse response analysis**

Impulse response functions (IRFs) (see Figure 5) are used to analyze causal dynamics beyond the current period, as the Granger causality test only captures contemporaneous relationships (Tiwari & Tiwari, 2010).

Figure 5 shows that a shock to GDP per capita leads to growth until period five, followed by a decline. A shock to MILIT boosts GDP per capita for two periods, then declines before turning positive again in periods eight to ten. INVE increases GDP per capita, but the effect fades after nine periods. Education impacts GDP per capita positively after period four, while population effects become significant after period six.

Regarding the responses of INVE, the findings suggest that after a shock to INVE, there appears a gradual fading positive effect to itself until the eight-time period when it becomes insignificant. In addition, GDPpc shocks increase INVE for six periods before declining while MILIT shocks consistently boost INVE from period one to ten. Further, EDUC shocks raise INVE until period five, then decline before turning positive in periods eight to ten. Finally, POPU shocks negatively impact INVE until period six but turn positive after period seven.

Observing the responses of EDUC, the findings suggest that subsequent a shock to EDUC, there appears a gradual fading positive effect to itself. In addition, a GDPpc shock gradually increases EDUC over ten periods while an INVE shock consistently reduces EDUC while a MILIT shock has no significant impact on EDUC until period six but declines significantly from periods seven to ten. Finally, a POPU shock negatively affects INVE until period six, turning positive after period seven.

Concerning the responses of POPU, a POPU shock initially has a fading positive impact to itself until period two, turns negative from periods three to eight, and then reverses to a positive impact from periods nine to ten. A GDPpc shock increases POPU until period six, then declines. An INVE shock boosts POPU until period six but becomes insignificant afterward. A MILIT shock negatively impacts POPU from period three, turning positive after period nine. An EDUC shock significantly reduces POPU from periods one to eight but turns positive until period ten.

Regarding the responses of MILIT, A MILIT shock has a fading positive impact to itself until period six, then turns negative from periods seven to ten. A GDPpc shock increases MILIT until period five before declining. An INVE shock boosts MILIT until period three but becomes insignificant afterward. A POPU shock is initially insignificant but positively impacts MILIT from periods five to ten. An EDUC shock significantly raises MILIT from periods one to six, turns negative for two years, and then remains positive until period ten. In retrospect, the causal dynamics retrieved from impulse response functions are identical to those of the VECM Granger causality analysis.

## 8 Conclusions

The present research examined the impact of the compositional effects of military spending on economic development in Greece, taking into account the academic discussion on military spending and economic development, as well as security issues. The research concentrated on a variety of econometric and statistical tests that assessed both short- and long-term effects in order to generate more definitive conclusions.

Greece serves as a compelling example, as its military expenditures have persistently surpassed 2% of GDP for the last four and half decades. Thus, the study's findings have practical implications for both developed and developing nations. Many countries are considering increasing their military expenditures in response to escalating geopolitical challenges. This study's results offer valuable policy insights by identifying the most efficient defence spending to sustain economic growth.

The present empirical investigation holds theoretical significance, chiefly in three critical results pertaining to its primary hypotheses. First, in the case of Greece defence expenditure has stimulated economic expansion in the short run but hindered it in the long run. Secondly, our findings reveal that military outlays dedicated to workforce salaries and pensions exert the greatest pronounced and divergent impact on economic growth compared to other categories of military outlays. Finally, the findings reveal the existence of a strong feedback relationship between economic growth and military spending.

Our research offers substantial policy ramifications for the distribution of military resources and budget to eventually promote sustained growth rates. First, government and military officials

must acknowledge that excessive military expenditure obstructs sustainable economic growth. Therefore, it is imperative to distribute solely the funds required for national security. If Greek governments continue to increase the military budget regardless of their economic capabilities, disproportionate and poorly strategized defence expenditures will result in fiscal imbalances, high public debt, and the need for increased tax revenue collection, which will displace private investments and insufficient funding for critical sectors of the economy, including public education, health, infrastructure, and social protection.

Second, policymakers must assess alternative defence expenditure strategies that could alleviate the adverse long-term impacts on economic growth. These strategies include prioritizing technological innovations, fostering international defence partnerships, addressing institutional shortcomings related to corruption, and enhancing the capacity of public institutions to manage public affairs and resources effectively.

Third, the decomposition analysis of military outlays indicates that spending on military equipment has a comparatively moderate impact on economic growth—beneficial in the short run but harmful in the long run. Greece, in particular, has allocated a substantial sum to importing military equipment, which constitutes a significant segment of its military budgets. Consequently, Greece ought to prioritize the national production of armaments and technology rather than relying on costly foreign alternatives

Fourth, military personnel spending has a substantial and complex effect on Greece's economic growth. While it may temporarily increase internal demand and subsequently economic expansion, it does not result in sustained increases in production or investment capacity over the long term. Political motives heavily influence personnel expenditures, exacerbating their negative effects and increasing economic burdens. However, shrinking military labour force could increase low wages and impoverishment among unskilled labourers and exacerbate youth unemployment. This, in turn, may affect short-term economic growth and governmental stability, particularly in countries that maintain significant military armed forces as a percentage of total labour of the economy.

Finally, to address the aforementioned concerns and mitigate unavoidable opportunity costs, the results suggest that governments should prioritize expanding operations and maintenance expenditures. Greece's defense strategy could be aligned with that of Nordic nations, which maintain sizable reserves. This approach would involve increasing military spending on operations and maintenance by 10%, bringing it closer to the NATO average of 24%. Conversely, personnel expenditures would be reduced by 10%, aligning more closely with NATO's average of 55%.

This examination offered a validated framework for analysing the relationship between disaggregated military expenditure and economic development. Aside from this, single-country investigations are influenced by factors like a nation's size, history, political regime, economic structure, and geopolitical location, resulting in varying impacts of military outlays on economic growth. Future empirical research could extend this analysis by conducting comparative studies on the impact of disaggregated military outlays on economic growth across multiple countries, particularly by contrasting developed and developing economies or nations with differing geostrategic conditions.

## References

- Ahad, M., & Dar, A. A. (2017). Modelling the asymmetric impact of defence spending on economic growth: An evidence from non-linear ARDL and multipliers. *Journal of Economic and Administrative Sciences*, 33(2), 131-149. <https://doi.org/10.1108/JEAS-03-2017-0010>
- Ahmed, S., Alam, K., Rashid, A., & Gow, J. 2020. "Militarisation, energy consumption, CO2 emissions and economic growth in Myanmar". *Defence and Peace Economics*, 31(6), 615-641. <https://doi.org/10.1080/10242694.2018.1560566>
- Ahmed, Z., Zafar, M. W., & Mansoor, S. (2020). Analysing the linkage between military spending, economic growth, and ecological footprint in Pakistan: evidence from cointegration and bootstrap causality. *Environmental Science and Pollution Research*, 27, 41551-41567. <https://doi.org/10.1007/s11356-020-10076-9>
- Aijaz Syed, A. 2021. "The asymmetric relationship between military expenditure, economic growth and industrial productivity: An empirical analysis of India, China and Pakistan via the NARDL approach." *Revista Finanzas y Política Económica*, 13(1), 77-97. <https://doi.org/10.14718/revfinanzpolitecon.v13.n1.2021.4>
- Aizenman, J., & Glick, R. (2003). Military expenditure, threats, and growth. In National Bureau of Economic Research. Working Paper No. 9618 <https://doi.org/10.3386/w9618>  
<https://doi.org/10.2139/ssrn.390764>
- Ajala, O., & Laniran, T. 2021. "Military Expenditure and Economic Growth: Evidence from Nigeria." *American Journal of Economics*. ISSN 2166-4951
- Akaike, H. (1974). A new look at the statistical model identification. *IEEE transactions on automatic control*, 19(6), 716-723. <https://doi.org/10.1109/TAC.1974.1100705>
- Antonakis, N. (1997). Military expenditure and economic growth in Greece, 1960-90, *Journal of Peace Research*, 34(1), 89-100. doi. 10.1177/0022343397034001007 <https://doi.org/10.1177/0022343397034001007>
- Antonakis, N. (1999). Guns versus butter: A multisectoral approach to military expenditure and growth with evidence from Greece, 1960-1993. *Journal of Conflict Resolution*, 43(4), 501-520. <https://doi.org/10.1177/0022002799043004005>
- Azam, M. 2020. Does military spending stifle economic growth?." *The empirical evidence from non-OECD countries*. *Heliyon*, 6(12). <https://doi.org/10.1016/j.heliyon.2020.e05853>
- Aziz, N., and Asadullah, M. N. (2017). Military spending, armed conflict and economic growth in developing countries in the post-Cold War era. *Journal of Economic Studies*, 44(1), 47-68. <https://doi.org/10.1108/JES-01-2015-0021>
- Balfoussias, A., & Stavrinou, V. (1996). The Greek military sector and macroeconomic effects of military spending in Greece. in *The Peace Dividend*, ed. Gleditsch et al., North Holland Publications, , pp. 191-213. [https://doi.org/10.1108/S0573-8555\(1996\)0000235012](https://doi.org/10.1108/S0573-8555(1996)0000235012)

Bårdsen, G. (1989). Estimation of long run coefficients in error correction models. *Oxford Bulletin of Economics and Statistics*, 51(3), 345-350.

<https://doi.org/10.1111/j.1468-0084.1989.mp51003008.x>

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of political economy*, 98(5, Part 2), S103-S125.

<https://doi.org/10.1086/261726>

Becker, J., & Dunne, J. P. (2023). Military spending composition and economic growth. *Defence and Peace Economics*, 34(3), 259-271.

<https://doi.org/10.1080/10242694.2021.2003530>

Becker, J., & Malesky, E. (2017). The continent or the "grand large"? Strategic culture and operational burden-sharing in NATO. *International studies quarterly*, 61(1), 163-180.

<https://doi.org/10.1093/isq/sqw039>

Becker, J., Benson, S., Dunne, J. P., & Malesky, E. (2024). Disaggregated defense spending: Introduction to data. *Journal of Peace Research*, 00223433231215785.

<https://doi.org/10.1177/00223433231215785>

Becker, J., Lute D., and Webster A. (2024). The Time for Europe to Step Up Is Now. Available at:

<https://warontherocks.com/2024/05/the-time-for-europe-to-step-up-is-now/>

Benoit, E. (1978). Growth and defence in developing countries. *Economic development and cultural change*, 26(2), 271-280.

<https://doi.org/10.1086/451015>

Bove, V., & Cavatorta, E. (2012). From conscription to volunteers: budget shares in NATO defence spending. *Defence and Peace Economics*, 23(3), 273-288.

<https://doi.org/10.1080/10242694.2011.563973>

Callado-Muñoz, F. J., Hromcová, J., & Utrero-González, N. (2019). Trade and Military Alliances: Evidence from NATO. *Peace Economics, Peace Science and Public Policy*, 25(4), 20190027.

<https://doi.org/10.1515/peps-2019-0027>

Chang, T., Lee, C. C., & Chu, H. P. (2015). Revisiting the Defence-Growth nexus in European countries. *Defence and Peace Economics*, 26(3), 341-356.

<https://doi.org/10.1080/10242694.2013.832556>

Chletsos, M., & Kollias, C. (1995). Defence expenditure and growth in Greece 1974-90: some preliminary econometric results, *Applied Economics*, 27(9), 883-890. doi. 10.1080/00036849500000042.

<https://doi.org/10.1080/00036849500000042>

Corruption Perception Index (2024). Available at: <https://www.transparency.org/en/>

De Waal, T., van Delden, A., & Scholtus, S. (2019). Quality measures for multisource statistics. *Statistical Journal of the IAOS*, 35(2), 179-192.

<https://doi.org/10.3233/SJI-180468>

Dimitraki, O., & Emmanouilidis, K. 2023. "Analysis of the Economic Effects of Defence Spending in Spain: A Re-Examination Through Dynamic ARDL Simulations and Kernel-Based Regularized Least Squares." *Defence and Peace Economics*, 1-23.

<https://doi.org/10.1080/10242694.2023.2245698>

Dimitraki, O., & Win, S. 2021. "Military expenditure economic growth nexus in Jordan: An application of ARDL Bound test analysis in the presence of breaks." *Defence and Peace Economics*, 32(7), 864-881.

<https://doi.org/10.1080/10242694.2020.1730113>

Dritsakis, N. (2004). Defence spending and economic growth: an empirical investigation for Greece and Türkiye. *Journal of Policy Modeling*, 26(2), 249-264.

<https://doi.org/10.1016/j.jpolmod.2004.03.011>

Dunne, J. P., & Nikolaidou, E. (2005). Military spending and economic growth in Greece, Portugal and Spain. *Frontiers in Finance and Economics*, 2(1), 1-17.

Dunne, J. P., & Nikolaidou, E. (2012). Defence spending and economic growth in the EU15. *Defence and Peace Economics*, 23(6), 537-548.

<https://doi.org/10.1080/10242694.2012.663575>

Dunne, J. P., & Smith, R. P. 2020. "Military expenditure, investment and growth." *Defence and Peace Economics*, 31(6), 601-614.

<https://doi.org/10.1080/10242694.2019.1636182>

Dunne, J. P., & Uye, M. (2010). Military spending and development. *The global arms trade: a handbook*. London: Routledge, 293-305.

<https://doi.org/10.4324/9780203851456-25>

Dunne, J. P., Smith, R. P., & Willenbockel, D. (2005). Models of military expenditure and growth: A critical review. *Defence and Peace Economics*, 16(6), 449-461.

<https://doi.org/10.1080/10242690500167791>

Dunne, P., & Nikolaidou, E. (2001). Military expenditure and economic growth: A demand and supply model for Greece, 1960-96. *Defence and Peace Economics*, 12(1), 47-67.

<https://doi.org/10.1080/10430710108404976>

Dunne, P., Nikolaidou, E., & Vougas, D. (2001). Defence spending and economic growth: A causal analysis for Greece and Türkiye, *Defence & Peace Economics*, 12(1), 5-26. doi. 10.1080/10430710108404974.

<https://doi.org/10.1080/10430710108404974>

*Economist* (2024). Available at: <https://www.economist.com/leaders/2024/02/22/caught-between-putin-and-trump>

Elliott, G., Rothenberg, T.J. and Stock, J.H. (1996). "Efficient Tests for an Autoregressive Unit Root," *Econometrica*, 64, 813-836.

<https://doi.org/10.2307/2171846>

Emmanouilidis, K. 2024. "Military Spending and Economic Output: A Decomposition Analysis of the US Military Budget." *Defence and Peace Economics*, 35(2), 243-263.

<https://doi.org/10.1080/10242694.2022.2145717>

Emmanouilidis, K., & Karpetsis, C. 2021. "The effects of military expenditures on economic growth and inflation: evidence from Turkey." *Peace Economics, Peace Science and Public Policy*, 27(3), 369-404.

<https://doi.org/10.1515/peps-2020-0058>

Faini, R., Annez, P., & Taylor, L. (1984). Defence spending, economic structure, and growth: Evidence among countries and over time. *Economic development and cultural change*, 32(3), 487-498.

<https://doi.org/10.1086/451402>

Geng, L., Abban, O.J., Hongxing, Y. et al. Do military expenditures impede economic growth in 48 Islamic countries? A panel data analysis with novel approaches. *Environ Dev Sustain* 26, 18725-18759 (2024).

<https://doi.org/10.1007/s10668-023-03413-8>

<https://doi.org/10.1007/s10668-023-03413-8>

Georgantopoulos, A. G. (2012). A Causal Analysis of the Defence-Growth Relationships: Evidence from the Balkans. *European Scientific Journal/April Edition*, 8(7).

Gonzalez, J. A., & Simpson, J. (2021). The workplace integration of veterans: Applying diversity and fit perspectives. *Human Resource Management Review*, 31(2), 100775.  
<https://doi.org/10.1016/j.hrmr.2020.100775>

Gujarati, D. N., & Porter, D. C. (2009). *Basic Econometrics*. McGraw-Hill/Irwin.

Heo, U. 2010. "The Relationship between Defence Spending and Economic Growth in the United States." *Political Research Quarterly* 63 (4): 760-770. doi:10.1177/1065912909334427  
<https://doi.org/10.1177/1065912909334427>

Hosmer Jr, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression*. John Wiley & Sons.  
<https://doi.org/10.1002/9781118548387>

Hung-Pin, L., & Tsung-Li, W. A. N. G. 2022. "Does Military Expenditure Promote Economic Growth and Social Welfare? Theoretical And Empirical Evidence in Taiwan." *Economic Computation & Economic Cybernetics Studies & Research*, 56(2).  
<https://doi.org/10.24818/18423264/56.2.22.05>

Islam, M. R. (2017). Income inequality and economic growth nexus in Japan: A multivariate analysis. *The Ritsumeikan economic review: the bi-monthly journal of Ritsumeikan University*, 65(4), 439-456.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration-with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.  
<https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x>

Kao, C., & Chiang, M. H. (2001). On the estimation and inference of a cointegrated regression in panel data. In *Nonstationary panels, panel cointegration, and dynamic panels* (pp. 179-222). Emerald Group Publishing Limited.  
[https://doi.org/10.1016/S0731-9053\(00\)15007-8](https://doi.org/10.1016/S0731-9053(00)15007-8)

Khalid, M. A., & Noor, Z. M. (2015). Military expenditure and economic growth in developing countries: evidence from system GMM estimates. *Journal of Emerging Trends in Economics and Management Sciences*, 6(1), 31-39.

Kollias, C. (1995). Preliminary findings on the economic effects of Greek military expenditure, *Applied Economics Letters*, 2(1), 16-18. doi. 10.1080/135048595357735"  
<https://doi.org/10.1080/135048595357735>

Kollias, C., & Paleologou, S. M. (2016). Investment, growth, and defence expenditure in the EU15: Revisiting the nexus using SIPRI's new consistent dataset. *The Economics of Peace and Security Journal*, 11(2).  
<https://doi.org/10.15355/epsj.11.2.28>

Kollias, C., & Tzeremes, P. 2022. "Militarization, investment, and economic growth 1995-2019." *Economics of Peace and Security Journal*, 17(1), 17-29.  
<https://doi.org/10.15355/epsj.17.1.17>

Kollias, C., and Makrydakis, S. (2000). A note on the causal relationship between defence spending and growth in Greece: 1955-93. *Defence and peace economics*, 11(1), 173-184.  
<https://doi.org/10.1080/10430710008404945>

Lanrui, L., Rahman, Z. U., Khattak, S. I., & Hassan, M. M. (2022). Asymmetric effect of military expenditures on economic growth in Pakistan: A nonlinear-ARDL approach. *Engineering Economics*, 33(3), 316-325.  
<https://doi.org/10.5755/j01.ee.33.3.28982>

Li, B., Ge, Y., & Lin, Y. M. (2023). Military alliance and international trade: Evidence from NATO enlargement. *The World Economy*.  
<https://doi.org/10.1111/twec.13426>

- Luqman, M., & Antonakakis, N. (2021). Guns better than butter in Pakistan? The dilemma of military expenditure, human development, and economic growth. *Technological Forecasting and Social Change*, 173, 121143. <https://doi.org/10.1016/j.techfore.2021.121143>
- Lütkepohl, H. 1982. "Non-causality due to omitted variables." *Journal of econometrics*, 19(2-3), 367-378. [https://doi.org/10.1016/0304-4076\(82\)90011-2](https://doi.org/10.1016/0304-4076(82)90011-2)
- Maher, M., & Zhao, Y. (2022). Do political instability and military expenditure undermine economic growth in Egypt? Evidence from the ARDL approach. *Defence and Peace Economics*, 33(8), 956-979. <https://doi.org/10.1080/10242694.2021.1943625>
- Malizard, J. (2013). Is There Military Keynesianism? an Evaluation of the Case of France Based on Disaggregated Data. Document de Travail ART-Dev 4.
- Malizard, J. (2016). Military expenditure and economic growth in the European Union: evidence from SIPRI's extended dataset. *The Economics of Peace and Security Journal*, 11(2). <https://doi.org/10.15355/epsj.11.2.38>
- Mark, N. C., & Sul, D. (2003). Cointegration vector estimation by panel DOLS and long-run money demand. *Oxford Bulletin of Economics and statistics*, 65(5), 655-680. <https://doi.org/10.1111/j.1468-0084.2003.00066.x>
- Mohanty, R. K., Panda, S., & Bhuyan, B. (2020). Does defence spending and its composition affect economic growth in India?. *Margin: The Journal of Applied Economic Research*, 14(1), 62-85. <https://doi.org/10.1177/0973801019886486>
- Murdoch, J. C., Sandler, T., & Sargent, K. (1997). A tale of two collectives: sulphur versus nitrogen oxides emission reduction in Europe. *Economica*, 64(254), 281-301. doi:<https://doi.org/10.1111/1468-0335.00078>
- Mylonidis, N. (2008). Revisiting the nexus between military spending and growth in the European Union. *Defence and Peace Economics*, 19(4), 265-272. <https://doi.org/10.1080/10242690802164801>
- NATO Database (2024). Available at: [https://www.nato.int/cps/en/natohq/topics\\_49198.htm](https://www.nato.int/cps/en/natohq/topics_49198.htm)
- Ng, S., & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), 1519-1554. <https://doi.org/10.1111/1468-0262.00256>
- Nikolaidou, E. (2016). The role of military expenditure and arms imports in the Greek debt crisis. *The Economics of Peace and Security Journal*, 11(1). <https://doi.org/10.15355/epsj.11.1.18>
- Olejnik, Ł. W. 2023. "Short-run multiplier effects of military expenditures in NATO's Eastern Flank countries in 1999-2021." *Journal of Comparative Economics*, 51(4), 1344-1355. <https://doi.org/10.1016/j.jce.2023.05.007>
- Paparas, D., Richter, C., & Paparas, A. (2016). Military Spending and economic growth in Greece and the Arms Race between Greece and Türkiye. *Journal of Economics Library*, 3(1), 38-56.
- Pesaran, M. H., Shin, Y., & Smith, R. J. 2001. "Bounds testing approaches to the analysis of level relationships." *Journal of applied econometrics*, 16(3), 289-326. <https://doi.org/10.1002/jae.616>

Phiri, A. (2019). Does military spending nonlinearly affect economic growth in South Africa?. *Defence and Peace Economics*, 30(4), 474-487.

<https://doi.org/10.1080/10242694.2017.1361272>

Pieroni, L. 2009. "Military expenditure and economic growth." *Defence and peace economics*, 20(4), 327-339.

<https://doi.org/10.1080/10242690701589876>

Pieroni, L., d'Agostino, G., & Lorusso, M. (2008). Can we declare military Keynesianism dead?. *Journal of Policy Modeling*, 30(5), 675-691.

<https://doi.org/10.1016/j.jpolmod.2008.02.005>

Rehman, A., Ma, H., Alvarado, R., & Ahmad, F. (2023). The nexus of military, final consumption expenditures, total reserves, and economic development of Pakistan. *Economic Change and Restructuring*, 56(3), 1753-1776.

<https://doi.org/10.1007/s10644-023-09490-z>

Schwarz, G. (1978). Estimating the dimension of a model. *The annals of statistics*, 461-464.

<https://doi.org/10.1214/aos/1176344136>

Serkan, K. Ü. N. Ü., Hopoğlu, S., & Bozma, G. (2016). Conflict, defence spending and economic growth in the middle east: A panel data analysis. *International Journal of Economics and Financial Issues*, 6(1), 80-86.

Shahbaz, M., Afra, T., & Shabbir, M. (2013). Does defence spending impede economic growth? Cointegration and causality analysis for Pakistan. *Defence and Peace Economics*, 24, 105-120.

<https://doi.org/10.1080/10242694.2012.723159>

SIPRI (2024). Available at: <https://www.sipri.org/databases/milex/sources-and-methods#definition-of-military-expenditure>

Su, C., Xu, Y., Chang, H. L., Lobont, O. R., & Liu, Z. 2020. "Dynamic causalities between defense expenditure and economic growth in China: evidence from rolling Granger causality test." *Defence and Peace Economics*, 31(5), 565-582.

<https://doi.org/10.1080/10242694.2018.1505583>

Teixeira, A. A., & Loureiro, A. S. (2019). FDI, income inequality and poverty: a time series analysis of Portugal, 1973-2016. *Portuguese Economic Journal*, 18(3), 203-249.

<https://doi.org/10.1007/s10258-018-00152-x>

Thadewald, T., & Büning, H. (2007). Jarque-Bera test and its competitors for testing normality-a power comparison. *Journal of applied statistics*, 34(1), 87-105.

<https://doi.org/10.1080/02664760600994539>

Tiwari, A. K., & Shahbaz, M. (2013). Does defence spending stimulate economic growth in India? A revisit. *Defence and Peace Economics*, 24(4), 371-395.

<https://doi.org/10.1080/10242694.2012.710814>

Tiwari, G., & Tiwari, R. (2010). Bioanalytical method validation: An updated review. *Pharmaceutical methods*, 1(1), 25-38.

<https://doi.org/10.4103/2229-4708.72226>

Tsitouras Antonis, Koulakiotis Athanasios, Makris Georgios and Papapanagos Harry (2017). International trade and foreign direct investment as growth stimulators in transition economies: does the impact of institutional factors matter?. *Investment Management and Financial Innovations*, 14(4), 148-170. doi:10.21511/imfi.14(4).2017.13

[https://doi.org/10.21511/imfi.14\(4\).2017.13](https://doi.org/10.21511/imfi.14(4).2017.13)

Tsitouras, A., Mitrakos, P., Tsimpida, C., Vlachos, V., & Bitzenis, A. (2020). An investigation into the causal links among FDI determinants: Empirical evidence from Greece. *Journal of East-West Business*, 26(1), 17-55.

<https://doi.org/10.1080/10669868.2019.1640829>

Ullah, S., Andlib, Z., Majeed, M. T., Sohail, S., & Chishti, M. Z. 2021. "Asymmetric effects of militarization on economic growth and environmental degradation: fresh evidence from Pakistan and India." *Environmental Science and Pollution Research*, 28, 9484-9497.

<https://doi.org/10.1007/s11356-020-11142-y>

UNESCO (2024). Available at: <http://data.uis.unesco.org/>

Wooldridge, J. M. (2016). *Introductory econometrics a modern approach*. South-Western cengage learning.

World Bank (2024). Available at: <https://data.worldbank.org/>

World Governance Indicators (2024). Available at: <https://www.worldbank.org/en/publication/worldwide-governance-indicators>

Yakovlev, P. (2007). Arms trade, military spending, and economic growth. *Defence and peace economics*, 18(4), 317-338.

<https://doi.org/10.1080/10242690601099679>

Yildirim, J., & Öcal, N. (2016). Military expenditures, economic growth and spatial spillovers. *Defence and Peace Economics*, 27(1), 87-104.

<https://doi.org/10.1080/10242694.2014.960246>

Yolcu Karadam, D., Yildirim, J., & Öcal, N. (2017). Military expenditure and economic growth in Middle Eastern countries and Türkiye: a non-linear panel data approach. *Defence and Peace Economics*, 28(6), 719-730.

<https://doi.org/10.1080/10242694.2016.1195573>

Zivot, E., & Andrews, D. W. K. (2002). "Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis". *Journal of business & economic statistics*, 20(1), 25-44.-44.

<https://doi.org/10.1198/073500102753410372>

**Figure 1. Military expenditure by country as a % of the GDP, 1980-2023**

**Figure 2. The % distribution of defence spending by each category in Greece and NATO**

**Figures 3a-f. Cusum plots and squares of recursive residuals**

**Figures 4a-h. Plots of dynamic multipliers**

**Figure 5. Impulse response analysis**

**Ethical Approval**

This study utilized publicly available secondary data, and therefore, ethical approval was not required.

**Informed Consent**

As this study involved the analysis of publicly available datasets, informed consent from individual participants was not required.

**Competing Interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Author Contributions:** Conceptualization: Antonis Tsitouras and Nicholas Tsounis; methodology: Antonis Tsitouras; software: Antonis Tsitouras; validation: Nicholas Tsounis; investigation: Antonis Tsitouras; data curation: Nicholas Tsounis; writing—original draft preparation: Antonis Tsitouras; writing—review and editing, Nicholas Tsounis; supervision, Nicholas Tsounis. All authors have read and agreed to the published version of the manuscript.

**Data Availability**

The data presented in this study are available upon reasonable request from the corresponding author.

Researches	Countries	Period	Type of Econometric Model	Estimation Technique	Conclusions
Chletsos & Kollias (1995)	Greece	1974-1990	Keynesian Model	Ordinary Least Square	The results do not support the hypothesis of achievement of the long-run equilibrium
Kollias (1995)	Greece	1963-1990	No Theoretical Model	Time Series Analysis with Granger causality with VAR	Positive effect of defense spending on economic growth
Balfoussias & Stavrinou (1996)	Greece	1960-1992	Keynesian Model	Time Series Analysis with 3SLS	Positive direct effect of defense spending on economic growth
Antonakis (1997)	Greece	1960-1990	Model of Simultaneous Equations	Time Series Analysis with OLS, 3SLS	Negative effect of defense spending on economic growth
Antonakis (1999)	Greece	1960-1993	Examples of the Feder-Ram type	Time Series Analysis Method from the general to the specific Harvey (1981)	The defense spending has a positive effect on economic growth
Kollias & Makrydakis (2000)	Greece	1955-1993	No Theoretical Model	Time Series Analysis with Granger causality with VAR	Absence of any causal relationship between defense spending and economic growth
Dunne & Nikolaidou (2001)	Greece	1960-1996	Model of Simultaneous Equations	Time Series Analysis with OLS, 2SLS, 3SLS	Negative direct effect of defense spending on economic growth
Dunne, et al. (2001)	Turkey and Greece	1960-1996	No Theoretical Model	Cointegration test Johansen (1988), Granger causality with VAR	Significant negative effect of defense spending on economic growth
Dritsakis (2004)	Turkey and Greece	1960-2001	No Theoretical Model	Time Series, Cointegration test Johansen (1988), causality vs Granger with VAR	There is no long-run effect of defense spending on economic growth
Dunne & Nikolaidou (2005)	Greece, Spain, Portugal	1960-2002	No Theoretical Model	Time Series, Granger causality with VAR, VECM	The results do not support the hypothesis of any specific effect of defense spending on economic growth
Mylonidis (2008)	15 European Union Members	1960-2000	Barro Type Model	Fixed effects panel model	The net effect of defense spending on economic growth is positive
Dunne & Nikolaidou (2012)	16 European Union Members	1961-2007	Augmented Solow Model	Fixed and Random effects panel model	Defense spending has a positive effect on economic growth
Georgantopoulos (2012)	Greece	1988-2009	No Theoretical Model	VAR Granger causality	Conflicting results regarding the effect of defense spending on economic growth, therefore impossible to confirm the existing relationship
Kollias & Paleologou (2016)	European Union of 15	1961-2014	No Theoretical Model	Panel Method Pedroni integration test, PVAR, IRF, VDA	Defense spending has a positive effect on economic growth, statistically significant
Malizard (2016)	European Union of 15	1960-2011	Augmented Solow Model	Panel Method PMG	Defense spending has a positive effect on economic growth
Manamperi (2016)	Greece, Turkey	1970-2013	Barro Type Model	Time Series, Bounds testing for integration control, VECM	Military spending has a positive impact on Turkey in the short and Greece's development by the level of economic growth

Nikolaidou (2016)	Spain, Greece, Portugal,	1960-2014	Augmented Solow Model	Ordinary Least Square	Absence of a relationship between growth both short and long run
Paparas, D., Richer, C. and Paparas, A. (2016)	Turkey and Greece	1957-2013	No Theoretical Model	Engle Granger Cointegration Analysis	Existence of a long run relationship between defence spending in economic growth

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Economic Growth

Total Defence Expenditure

Defence Expenditure in Equipment

Defence Expenditure in Personnel

Defence Expenditure in Infrastructure

Defence Expenditure in Other Expenses

Domestic Investment

Education

Population

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**Table 3. Summary Statistics of the Variables**

	<b>GDPpc<sub>t</sub></b>	<b>INVE<sub>t</sub></b>	<b>EDUC<sub>t</sub></b>	<b>POPU<sub>t</sub></b>	<b>MILIT<sub>t</sub></b>	<b>MILIT-EQUI<sub>t</sub></b>	<b>MILIT-PERS<sub>t</sub></b>	<b>MILIT-INFR<sub>t</sub></b>
<b>Mean</b>	9.79	20.09	73.07	43.69	9.06	7.21	8.64	4.59
<b>Median</b>	9.80	22.39	61.48	44.41	9.04	7.29	8.59	4.86
<b>Maximum</b>	10.09	30.66	152.00	68.65	9.80	8.71	9.40	6.00
<b>Minimum</b>	9.58	10.69	15.58	21.20	8.44	5.93	8.16	1.94
<b>Std. Dev.</b>	0.15	5.82	47.40	14.14	0.35	0.63	0.32	0.97
<b>Skewness</b>	0.37	-0.47	0.38	-0.01	0.11	0.02	0.57	-0.74
<b>Kurtosis</b>	2.06	1.85	1.67	1.75	2.04	3.02	2.41	2.99
<b>Jarque-Bera</b>	2.63	4.04	4.28	2.87	1.78	0.03	3.07	4.03
<b>Probability</b>	0.27	0.13	0.12	0.24	0.41	0.99	0.22	0.13
<b>Sum</b>	430.77	884.12	3,215.03	1,922.52	398.76	317.43	379.96	202.07
<b>Sum Sq. Dev.</b>	0.97	1,456.99	96,627.20	8,600.26	5.15	17.11	4.43	40.63
<b>Observations</b>	44	44	44	44	44	44	44	44

**Table 4. Results of VIF Test**

	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>	<b>Model 5</b>
<b>Variable</b>	<b>VIF</b>	<b>VIF</b>	<b>VIF</b>	<b>VIF</b>	<b>VIF</b>
INVE <sub>t</sub>	8.045	4.941	7.954	5.299	6.506
EDUC <sub>t</sub>	6.076	4.479	7.459	4.669	3.994
POPU <sub>t</sub>	5.893	5.924	5.905	6.042	6.184
MILIT <sub>t</sub>	2.455				
MILIT-EQUI <sub>t</sub>		1.431			
MILIT-PERS <sub>t</sub>			2.636		

MILIT- INFR <sub>t</sub>	3.319
MILIT- OTHE <sub>t</sub>	1.900

Source: Calculated by the authors via Eviews-14

**Table 5: Results of the Unit Root Tests**

Variables	DF-GLS		Ng-Perron		Zivot-A
	Constant	Constant & Trend	Constant	Constant & Trend	Constant
At Levels	Statistic	Statistic	Statistic	Statistic	Statistic
GDP <sub>pc,t</sub>	-1.072 (1)	-1.886 (1)	-2.972 (1)	-8.544 (1)	-4.334 (1)
INVE <sub>t</sub>	-0.548 (1)	-2.021 (1)	-1.086 (0)	-8.382 (0)	-4.823 (1)
EDUC <sub>t</sub>	0.895 (0)	1.371 (0)	1.742 (0)	-6.523 (0)	-3.089 (0)
POP <sub>U,t</sub>	1.268 (1)	-2.196 (1)	2.374 (3)	-7.741 (0)	-4.258 (4)
MILIT <sub>t</sub>	-1.904 (0)*	-1.908 (0)	-6.374 (0)*	-6.387 (0)	-4.770 (1)*
MILIT-EQUI <sub>t</sub>	-2.448 (2)**	-2.504 (2)*	-11.185 (0)**	-11.356 (1)	-3.865 (3)
MILIT-PERS <sub>t</sub>	-1.536 (0)*	-2.418 (2)	-4.320 (1)	-4.723 (0)	-4.479 (1)
MILIT-INFR <sub>t</sub>	0.540 (1)	-2.390 (1)	-1.850 (1)	-7.847 (1)	-2.961 (1)
MILIT-OTHE <sub>t</sub>	-1.728 (0)*	-2.581 (0)	-5.092 (0)	-11.853 (1)	-3.112 (1)
<b>At First Difference</b>					
GDP <sub>pc,t</sub>	-3.819 (0)***	-3.964 (0)**	-16.249 (0)***	-16.711 (0)***	-5.487 (0)**
INVE <sub>t</sub>	-4.822 (0)***	-5.467 (0)***	-19.159 (0)***	-20.322 (0)**	-6.711 (0)***
EDUC <sub>t</sub>	-3.715 (1)***	-4.172 (1)***	-17.759 (1)***	-21.722 (0)**	-6.327 (0)***
POP <sub>U,t</sub>	-5.079 (1)***	-5.055 (1)***	-8.908 (3)**	-36.840 (1)***	-5.215 (3)***
MILIT <sub>t</sub>	-3.615 (1)***	-4.105 (0)***	-15.466 (0)***	-18.997 (3)**	-5.282 (0)**
MILIT-EQUI <sub>t</sub>	-5.966 (1)***	-5.933 (1)***	-51.339 (0)***	-43.808 (1)***	-6.497 (1)***

MILIT-PERS <sub>t</sub>	-3.162 (0)***	-4.263 (0)***	-12.520 (0)**	-16.849 (0)*	-6.296 (0)***
MILIT-INFR <sub>t</sub>	-2.001 (1)**	-4.535 (1)***	-19.199 (0)***	-16.511 (0)**	-6.132 (0)***
MILIT-OTHE <sub>t</sub>	-4.538 (0)***	-5.151 (0)***	-14.515 (0)***	-19.601 (0)**	-5.463 (0)***

**Notes:** The DF-GLS, Ng-P and Zivot-Andrews tests' optimal lag structures are determined using the Akaike information criterion in parentheses.

At the 1%, 5%, and 10% levels, respectively, \*\*\*, \*\*, and \* indicate rejection of the null hypothesis of a unit root.

	Critical values for the DF-GLS test		Critical values for the NP (MZA) test		Critical values for the
	Constant	Constant & Trend	Constant	Constant & Trend	Constant
1%	-2.622	-3.770	-13.800	-23.800	-5.340
5%	-1.949	-3.190	-8.100	-17.300	-4.930
10%	-1.612	-2.890	-5.700	-14.200	-4.580

**Table 6. Lag Selection Criteria**

Estimated Model 1: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT_t)$						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-178.975	NA	0.007	9.199	9.410	9.275
1	7.028	316.205	0.000	1.149	2.415*	1.606*
2	38.606	45.788	0.000	0.820	3.142	1.659
3	59.523	25.101	0.000	1.024	4.402	2.245
4	99.593	38.066*	0.000*	<b>0.270*</b>	4.704	1.873

Estimated Model 2: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-EQUIP_t)$						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-219.239	NA	0.051	11.212	11.423	11.288
1	-33.713	315.394	0.000	3.186	4.452*	3.643*
2	-4.132	42.892	0.000	2.957	5.279	3.796
3	18.288	26.905	0.000	3.086	6.463	4.307
4	61.909	41.439*	0.000*	<b>2.154*</b>	6.588	3.757

Estimated Model 3: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-PERS_t)$						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-162.575	NA	0.003	8.379	8.590	8.455
1	18.304	307.493	0.000	0.585	1.851*	1.043

2	48.745	44.140	0.000	0.313	2.635	1.152
3	71.212	26.960	0.000	0.439	3.817	1.661
4	116.301	42.834*	0.000*	<b>-0.565*</b>	3.868	1.037*

**Estimated Model 4:  $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-INFR_t)$**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-216.621	NA	0.045	11.081	11.292	11.157
1	-44.921	291.889	0.000	3.746	5.012*	4.204
2	-15.970	41.979	0.000	3.549	5.871	4.388
3	9.652	30.747	0.000	3.517	6.895	4.739
4	50.521	38.825*	0.000*	<b>2.723*</b>	7.157	4.327

**Estimated Model 5:  $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-OTHE_t)$**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-197.764	NA	0.017	10.138	10.349	10.215
1	-6.552	325.062	0.000	1.828	3.094*	2.285*
2	23.096	42.988*	0.000	1.595	3.917	2.435
3	50.521	32.911	0.000	1.474	4.852	2.695
4	88.072	35.673	0.000*	<b>0.846*</b>	5.280	2.449

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

**Table 7. Johansen and Juselius (1990) Cointegration Test Results**

	Trace Statistic			
	Maximum rank (r)			
	None *	At most 1 *	At most 2 *	At most 3 *
Model 1: $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT_t)$	153.338***	66.838***	36.636***	16.849**
Model 2: $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-EQUI_t)$	188.895***	76.099***	39.165***	16.957**
Model 3: $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-PERS_t)$	158.449***	71.280**	37.099***	11.678**
Model 4: $GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-INFR_t)$	142.825***	76.941***	41.812***	17.403**

Model 5:  $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-OTHE_t)$

125.921\*\*\* 76.885\*\*\* 40.787\*\*\* 18.389\*\*

**Notes.** \*\*\* and \*\* indicate statistical significance at the 1% and 5% level. Models include a constant term. The lag length (k) is fixed by the minimum Akaike (AIC) criterion: k =4

**Table 8: The ARDL Cointegration Test Results**

ARDL Cointegration Results						
	Test Statistic		Value			
Model 1: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT_t)$	F-statistic:		12.674			
Model 2: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-EQU_t)$	F-statistic:		7.020			
Model 3: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-PERS_t)$	F-statistic:		12.056			
Model 4: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-INFR_t)$	F-statistic:		8.027			
Model 5: $GDPpc_t = f(INVE_t, EDUC_t, POPU_t, MILIT-OTHE_t)$	F-statistic:		14.160			
Bounds Critical Values						
	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-Statistic						
40	2.660	3.838	3.202	4.544	4.428	6.250

**Notes:**

The Akaike information criterion (AIC) was applied to select the ARDL model.

I(0) and I(1) denote the stationary and non-stationary bounds, accordingly.

The confidence levels are derived from Pesaran et al. (2001).

Eviews 14 was utilised to perform estimates and cointegration analyses.

**Table 9. The Short and Long Run Estimated Coefficients**

Estimated Model 1: Dependent Variable $GDPpc_t$		Estimated Model 1: Dependent Variable $GDPpc_t$	
<b>Selected Model:</b>	ARDL(1,0,4,4,2)	Dynamic Least Squares (DOLS)	

Variable	Coefficient	T-Ratio	Prob-value	Variable	Coefficient	T-Ratio	Prob-value
<b>Short-run Estimates</b>				<b>Short-run Estimates</b>			
$\Delta GDP_{pc,t-1}$							
$\Delta GDP_{pc,t-2}$							
$\Delta GDP_{pc,t-3}$							
$\Delta INVE_t$	0.017	4.392	(0.000)				
$\Delta INVE_{t-1}$							
$\Delta INVE_{t-2}$							
$\Delta EDUC_t$	0.002	0.851	(0.402)				
$\Delta EDUC_{t-1}$	-0.019	-	4.091 (0.000)				
$\Delta EDUC_{t-2}$	-0.021	-	5.121 (0.000)				
$\Delta EDUC_{t-3}$	-0.022	-	3.596 (0.001)				
$\Delta POPU_t$	0.028	0.972	(0.339)				
$\Delta POPU_{t-1}$	-0.117	-	3.922 (0.001)				
$\Delta POPU_{t-2}$	-0.074	-	3.092 (0.004)				
$\Delta POPU_{t-3}$	-0.129	-	5.433 (0.000)				
$\Delta MILIT_t$	0.015	0.729	(0.472)				
$\Delta MILIT_{t-1}$	0.091	3.814	(0.001)				
ECTerm	-0.418	-	5.972 (0.000)				
Intercept	4.010	5.975	(0.000)				
<b>Long-run Estimates</b>				<b>Long-run Estimates</b>			
$INVE_t$	0.040	4.739	(0.000)	$INVE_t$	0.033	5.949	(0.000)
$EDUC_t$	0.044	6.888	(0.000)	$EDUC_t$	0.030	12.199	(0.000)
$POPU_t$	0.321	2.722	(0.004)	$POPU_t$	0.071	1.916	(0.060)
$MILIT_t$	-0.157	-	3.049 (0.009)	$MILIT_t$	-0.102	-1.958	(0.065)
$R^2=0.814$				$R^2=0.923$			
Adj. $R^2=0.740$				Adj. $R^2=0.892$			
F-statistic=11.094				S.E. of regression=0.049			
Prob(F-statistic)=(0.000)							
<b>Notes:</b> $\Delta$ indicates first differences. P-values are reported in paratheses The HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000) are applied				Automatic leads and lags specification (lead=1 and lag=0 based on AIC criterion, max=4) HAC standard errors & covariance (None kernel)			

Estimated Model 2: Dependent Variable GDPpc <sub>t</sub>			
Selected Model:	ARDL(4,0,4,4,2)		
Variable	Coefficient	T-Ratio	Prob - value
<b>Short-run Estimates</b>			
$\Delta\text{GDPpc}_{t-1}$	0.161	1.57	(0.142)
$\Delta\text{GDPpc}_{t-2}$	0.178	1.760	(0.091)
$\Delta\text{GDPpc}_{t-3}$	0.298	1.946	(0.063)
$\Delta\text{INVE}_t$	0.013	3.959	(0.001)
$\Delta\text{INVE}_{t-1}$			
$\Delta\text{INVE}_{t-2}$			
$\Delta\text{INVE}_{t-3}$			
$\Delta\text{EDUC}_t$	0.004	1.675	(0.106)
$\Delta\text{EDUC}_{t-1}$	-0.020	2.606	(0.015)
$\Delta\text{EDUC}_{t-2}$	-0.021	3.409	(0.002)
$\Delta\text{EDUC}_{t-3}$	-0.018	2.463	(0.021)
$\Delta\text{POPU}_t$	0.072	2.504	(0.019)
$\Delta\text{POPU}_{t-1}$	-0.165	2.834	(0.009)

**Table 10.** The Short and Long-run estimates

Estimated Model 3: Dependent Variable GDPpc <sub>t</sub>			
Selected Model:	ARDL(4,3,4,4,3)		
Variable	Coefficient	T-Ratio	Prob - value
<b>Short-run Estimates</b>			
$\Delta\text{GDPpc}_{t-1}$	-0.080	1.183	(0.250)
$\Delta\text{GDPpc}_{t-2}$	0.013	0.254	(0.802)
$\Delta\text{GDPpc}_{t-3}$	0.340	3.905	(0.001)
$\Delta\text{INVE}_t$	0.014	5.730	(0.000)
$\Delta\text{INVE}_{t-1}$	-0.006	1.976	(0.061)
$\Delta\text{INVE}_{t-2}$	-0.006	3.254	(0.004)
$\Delta\text{INVE}_{t-3}$			
$\Delta\text{EDUC}_t$	0.005	1.985	(0.060)
$\Delta\text{EDUC}_{t-1}$	-0.021	4.606	(0.000)
$\Delta\text{EDUC}_{t-2}$	-0.020	4.744	(0.000)
$\Delta\text{EDUC}_{t-3}$	-0.023	4.290	(0.000)
$\Delta\text{POPU}_t$	0.034	1.057	(0.302)
$\Delta\text{POPU}_{t-1}$	-0.139	3.626	(0.002)

$\Delta\text{POPU}_{t-2}$	-0.061	3.322	(0.003)	$\Delta\text{POPU}_{t-2}$	-0.046	1.712	(0.102)
$\Delta\text{POPU}_{t-3}$	-0.158	3.328	(0.003)	$\Delta\text{POPU}_{t-3}$	-0.150	4.536	(0.000)
$\Delta\text{MILIT-EQUI}_t$	0.002	0.344	(0.734)	$\Delta\text{MILIT-PERS}_t$	0.035	1.323	(0.200)
$\Delta\text{MILIT-EQUI}_{t-1}$	0.022	2.468	(0.021)	$\Delta\text{MILIT-PERS}_{t-1}$	0.154	5.780	(0.000)
$\Delta\text{MILIT-EQUI}_{t-2}$				$\Delta\text{MILIT-PERS}_{t-2}$	0.049	2.847	(0.010)
ECTerm	-0.546	5.585	(0.000)	ECTerm	-0.477	4.491	(0.000)
Intercept	4.908	5.566	(0.000)	Intercept	4.978	4.511	(0.000)
<b>Long-run Estimates</b>				<b>Long-run Estimates</b>			
INVE <sub>t</sub>	0.024	8.006	(0.000)	INVE <sub>t</sub>	0.052	5.632	(0.000)
EDUC <sub>t</sub>	0.035	8.803	(0.000)	EDUC <sub>t</sub>	0.047	7.711	(0.000)
POPU <sub>t</sub>	0.297	4.247	(0.000)	POPU <sub>t</sub>	0.203	1.985	(0.055)
MILIT-EQUI <sub>t</sub>	-0.047	2.959	(0.005)	MILIT-PERS <sub>t</sub>	-0.297	3.848	(0.000)
R <sup>2</sup> =0.780				R <sup>2</sup> =0.888			
Adj.R <sup>2</sup> =0.657				Adj.R <sup>2</sup> =0.794			
F-statistic=6.330				F-statistic=9.331			
Prob(F-statistic)=(0.000)				Prob(F-statistic)=(0.000)			
Notes: $\Delta$ indicates first differences. p-values are presented in parentheses.							
The HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000) are applied							

**Table 10. Short and Long-run estimated Coeff**

<b>Estimated Model 1:Dependent Variable GDPpc<sub>t</sub></b>			
Dynamic Least Squares (DOLS)			
Variable	Coefficient	T-Ratio	Prob - value
<b>Long-run Estimates</b>			

<b>Estimated Model 1:Dependent Variable GDPpc<sub>t</sub></b>			
Dynamic Least Squares (DOLS)			
Variable	Coefficient	T-Ratio	Prob - value
<b>Long-run Estimates</b>			

INVE <sub>t</sub>	0.028	5.0 68	(0.00 0)	INVE <sub>t</sub>	0.044	10.7 94	(0.00 0)
EDUC <sub>t</sub>	0.028	8.6 77	(0.00 0)	EDUC <sub>t</sub>	0.034	22.4 86	(0.00 0)
POPU <sub>t</sub>	0.088	1.8 54	(0.07 6)	POPU <sub>t</sub>	0.063	1.21 8	(0.24 3)
MILIT-EQUI <sub>t</sub>	-0.045	- 1.929	(0.06 6)	MILIT-PERS <sub>t</sub>	-0.155	- 4.004	(0.00 1)
R <sup>2</sup> =0.938 Adj. R <sup>2</sup> =0.898 S.E. of regression=0.047				R <sup>2</sup> =0.988 Adj. R <sup>2</sup> =0.970 S.E. of regression=0.025			
Automatic leads and lags specification (lead=1 and lag=1 based on AIC criterion, max=4) HAC standard errors & covariance (None kernel)				Automatic leads and lags specification (lead=0 and lag=4 based on AIC criterion, max=4) HAC standard errors & covariance (None kernel)			

**Table 11. Diagnostic Tests for ARDL Models**

Model	Equation	Tests
<b>Estimated Model 1:</b>	$GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT_t)$	F-s p-v sta
<b>Estimated Model 2:</b>	$GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-EQUI_t)$	F-s p-v sta
<b>Estimated Model 3:</b>	$GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-PERS_t)$	F-s p-v sta
<b>Estimated Model 4:</b>	$GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-INFR_t)$	F-s p-v sta

Estimated Model 5:

$$GDP_{pc_t} = f(INVE_t, EDUC_t, POPU_t, MILIT-OTHE_t)$$

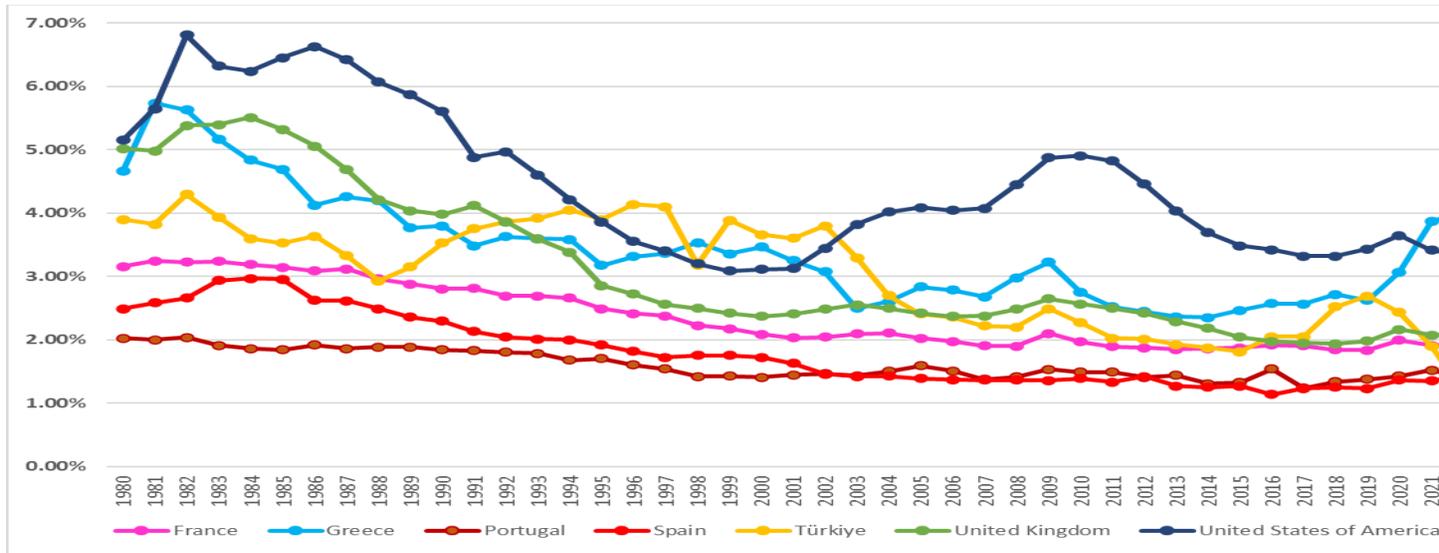
F-s  
p-v  
sta

Table 12. The Results of the VECM Granger Causality Test

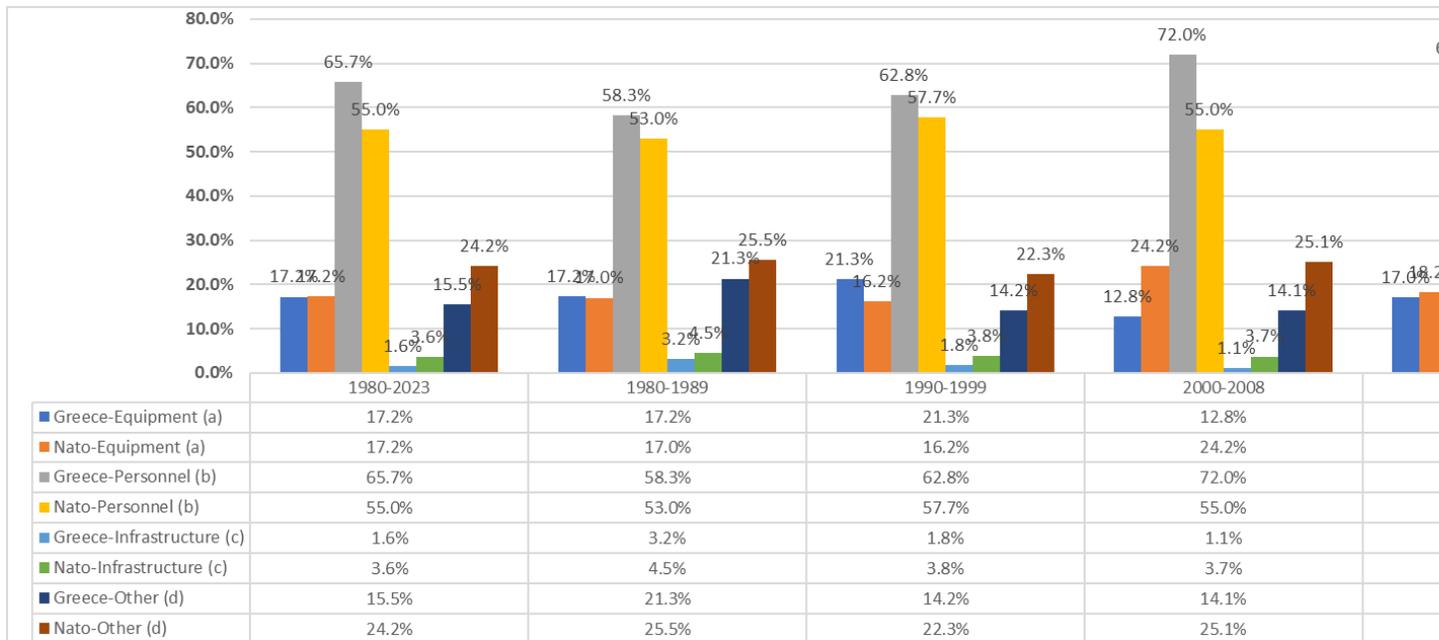
Dep. Var.	Wald test F-statistics - Short-run								
	$\Delta GDP_{pc_t}$	$\Delta INVE_t$	$EDUC_t$	$\Delta POPU_t$	$\Delta MILIT_t$				
$\Delta GDP_{pc_t}$		6.952 (0.138)	20.645 (0.000)***	8.185 (0.085)*	8.946 (0.003)**				
$\Delta INVE_t$	1.453 (0.834)		3.967 (0.410)	6.292 (0.178)	8.371 (0.004)**				
$\Delta EDUC_t$	1.908 (0.752)	2.713 (0.606)		3.987 (0.408)	3.993 (0.047)**				
$\Delta POPU_t$	2.856 (0.582)	4.854 (0.302)	2.114 (0.714)		6.810 (0.011)**				
$\Delta MILIT_t$	2.711 (0.607)	13.282 (0.009)***	14.201 (0.007)***	12.942 (0.011)**					
Diagnostics Tests		VEC Residual Serial Correlation LM Tests			VEC Residual Normality Tests				
Chi-sq		0.485			7.209				
Prob		0.967			0.206				

Note: \*\*\* ( \*\* and \* ) denote statistical significance at the 1 percent, 5 per cent and 10 percent respectively. The probability values for the short run and long causality are reported in parenthesis. Values in square parenthesis are of t-statistics.

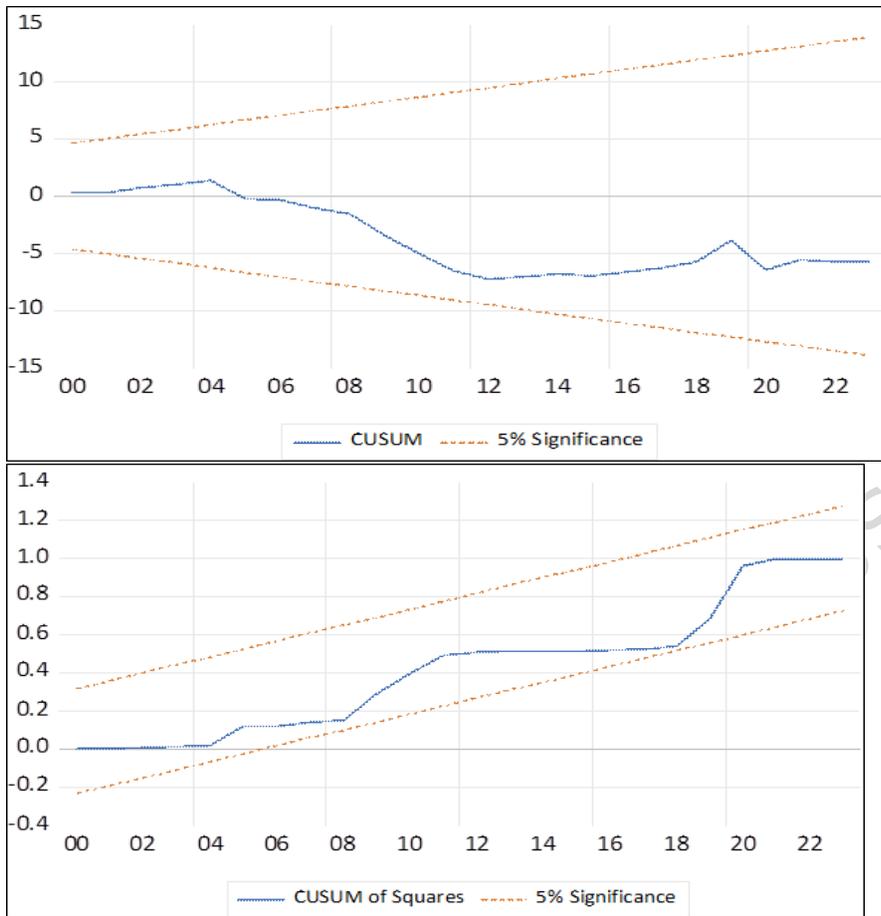
**Figure 1. Military expenditure by country as a % of the GDP, 1980-2023**

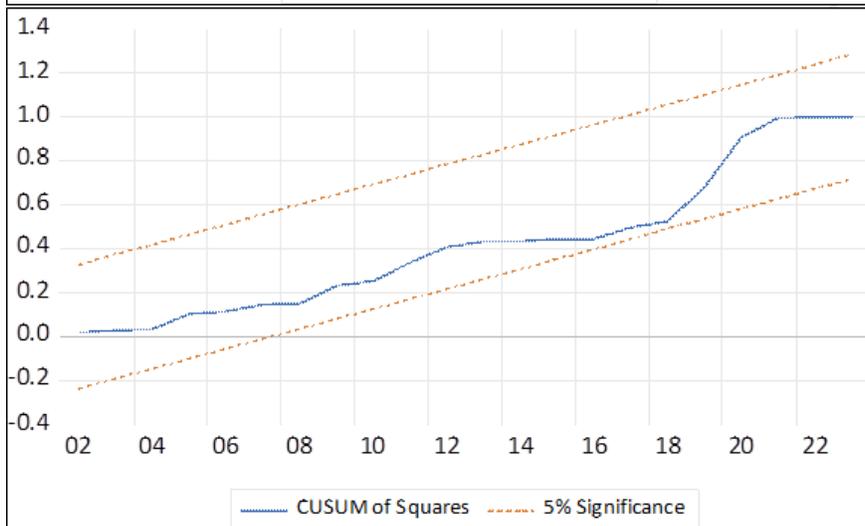
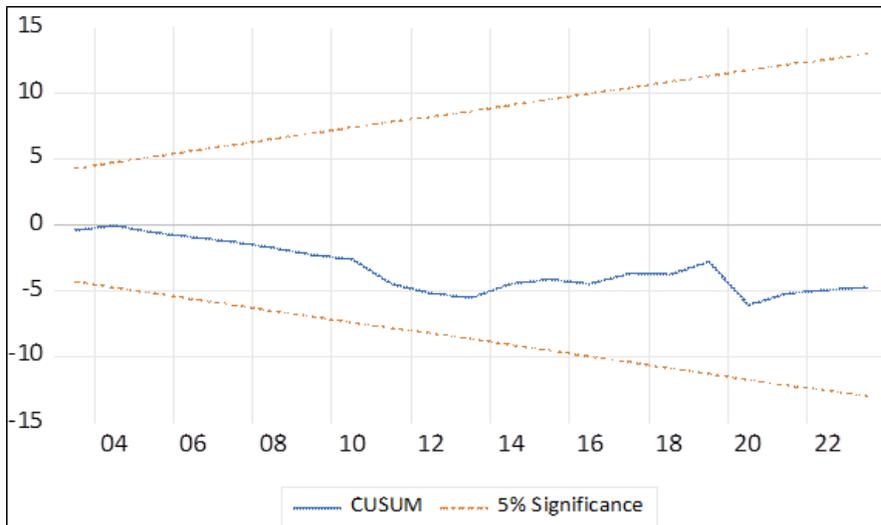


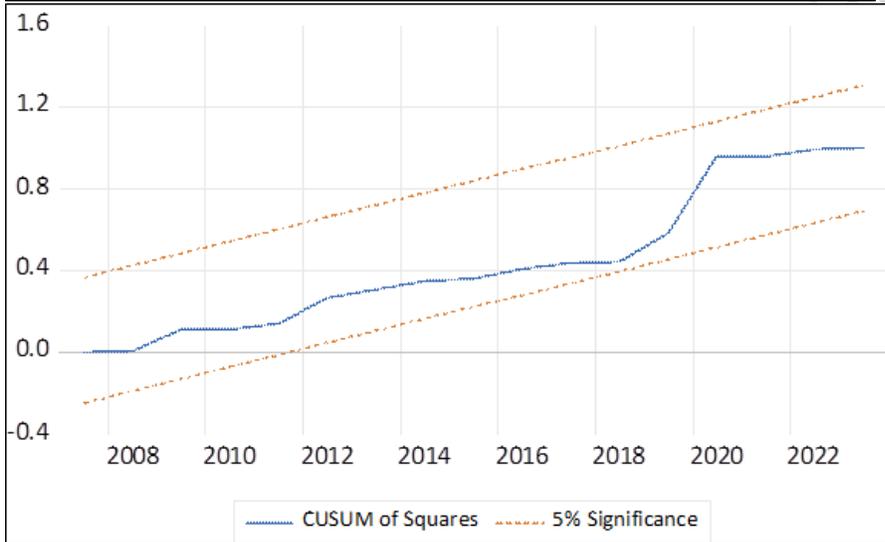
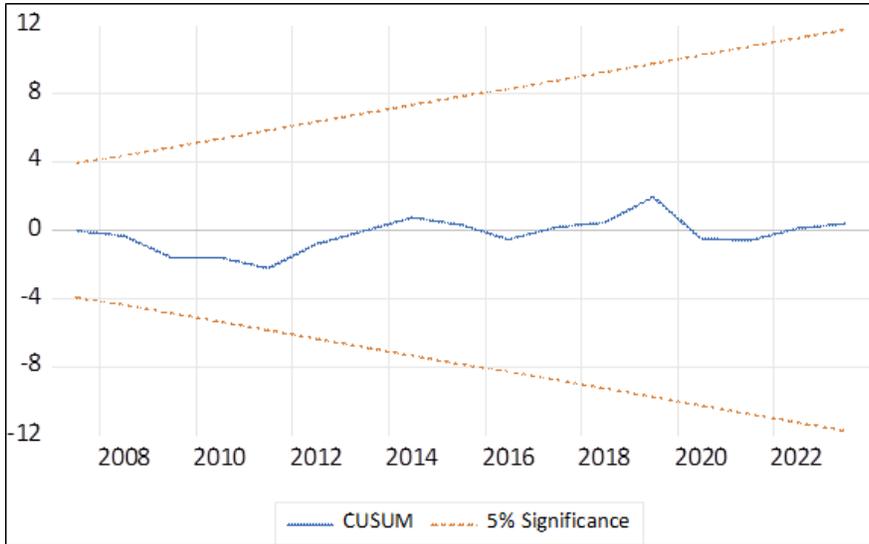
**Figure 2. The % distribution of defence spending by each category in Greece and NATO**

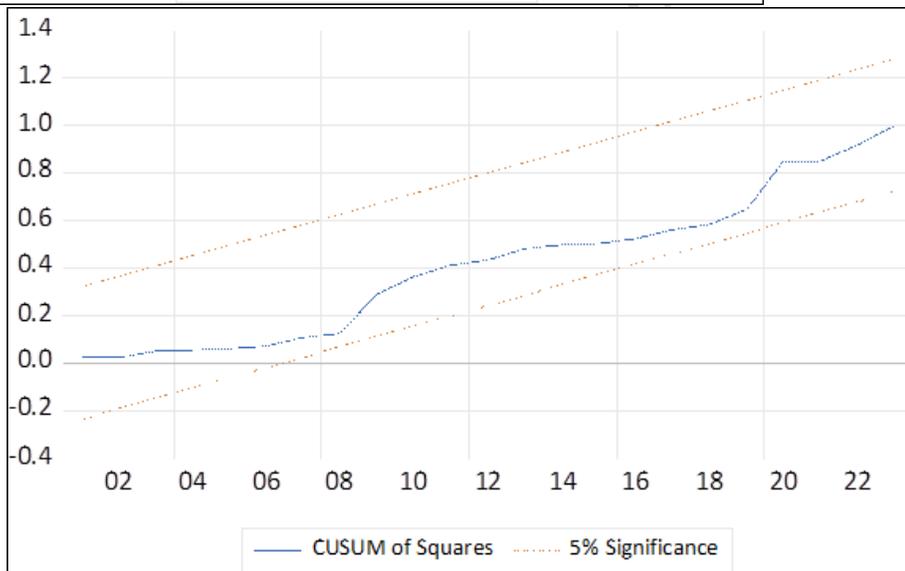
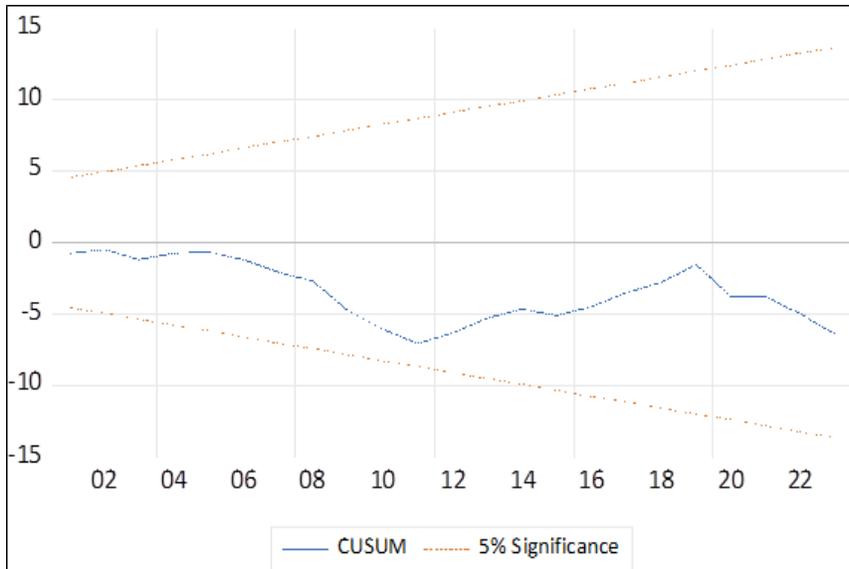


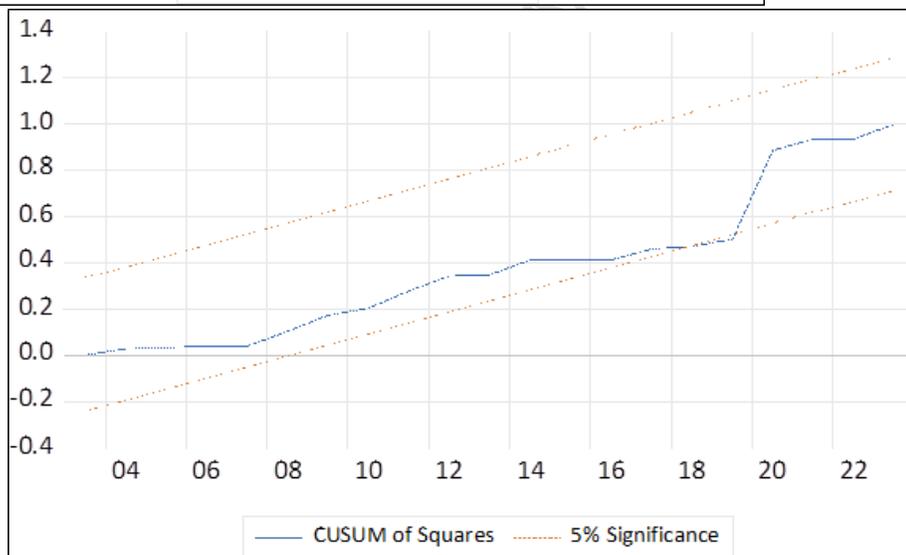
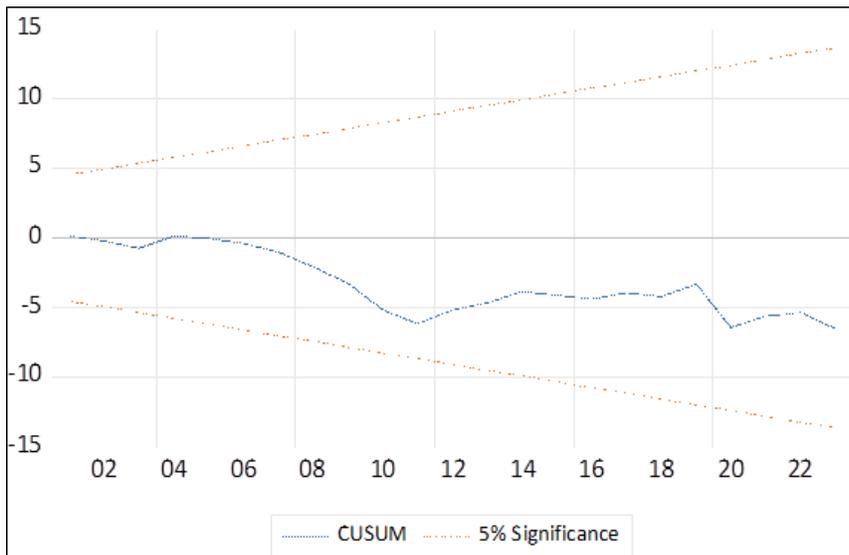
**Figures 3a-f. Plots of Cusum and Cusum of Squares of Recursive Residuals  
Model 1.**

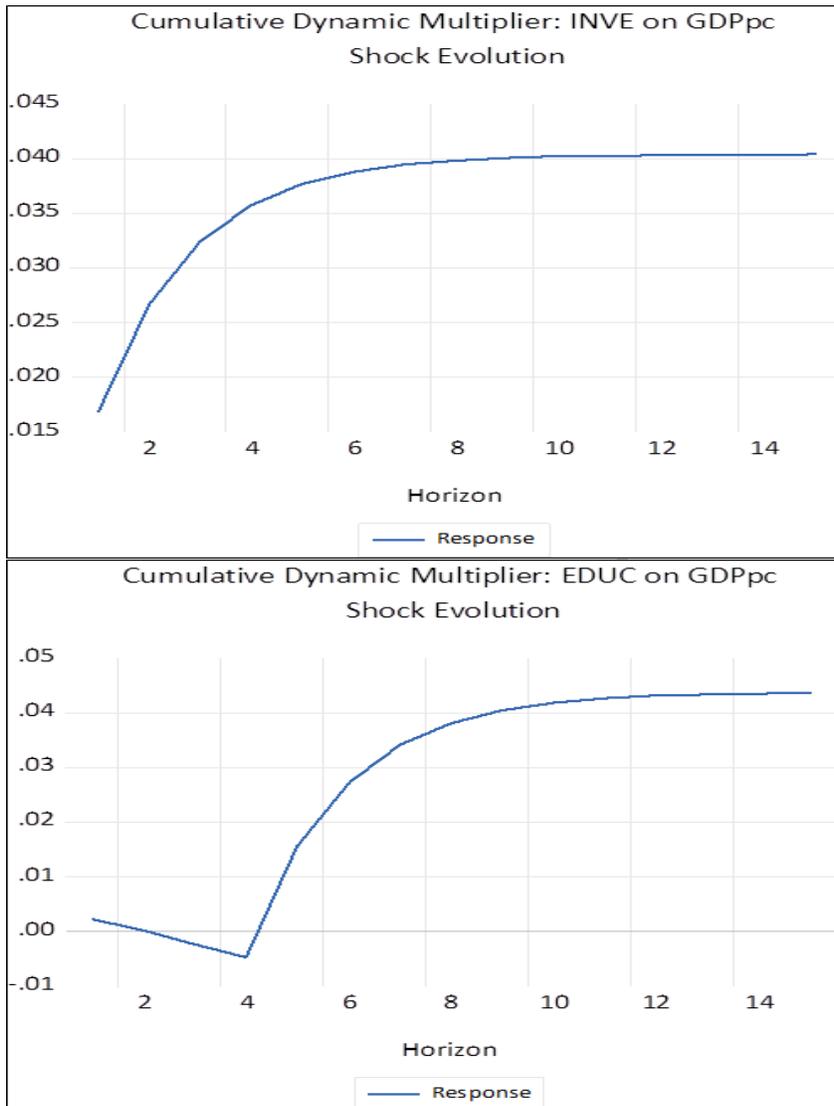
**Model 2.**

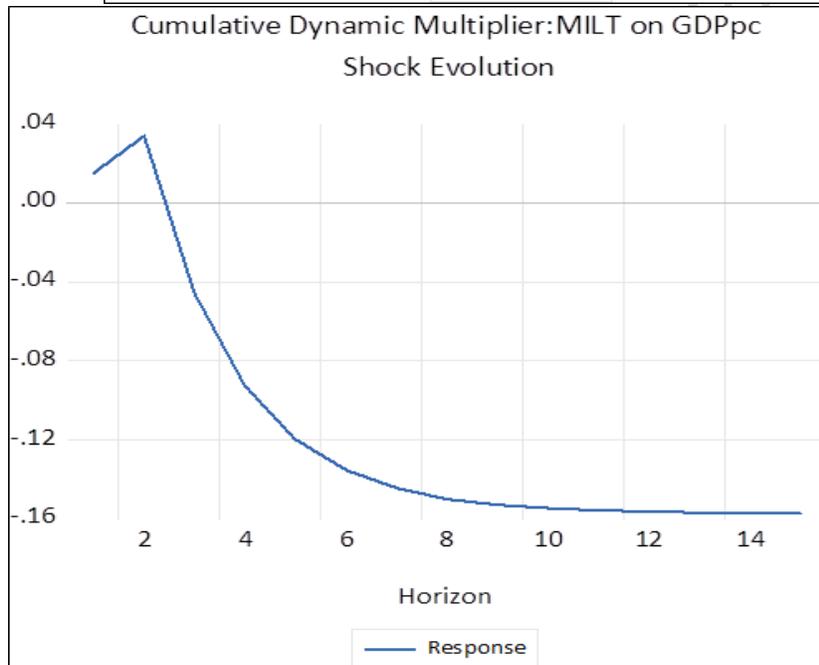
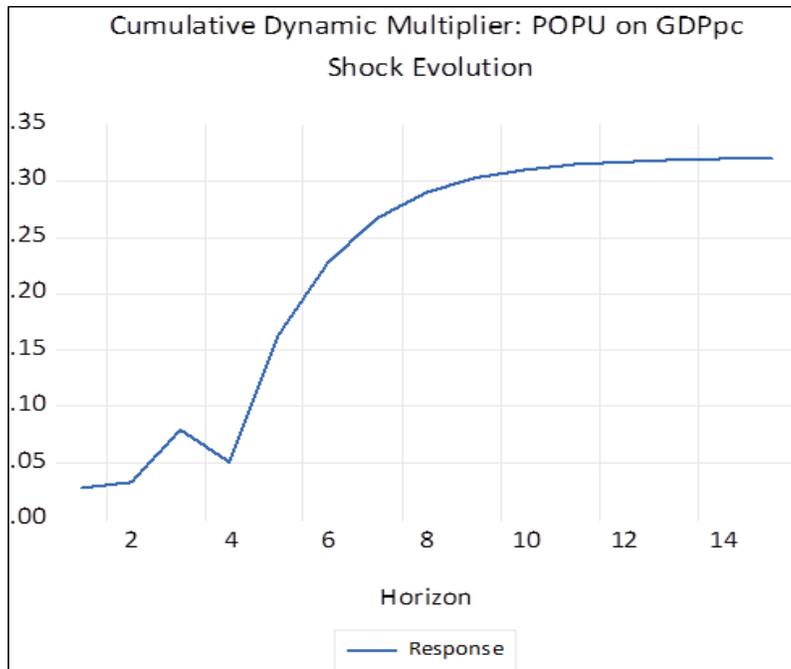
**Model 3.**

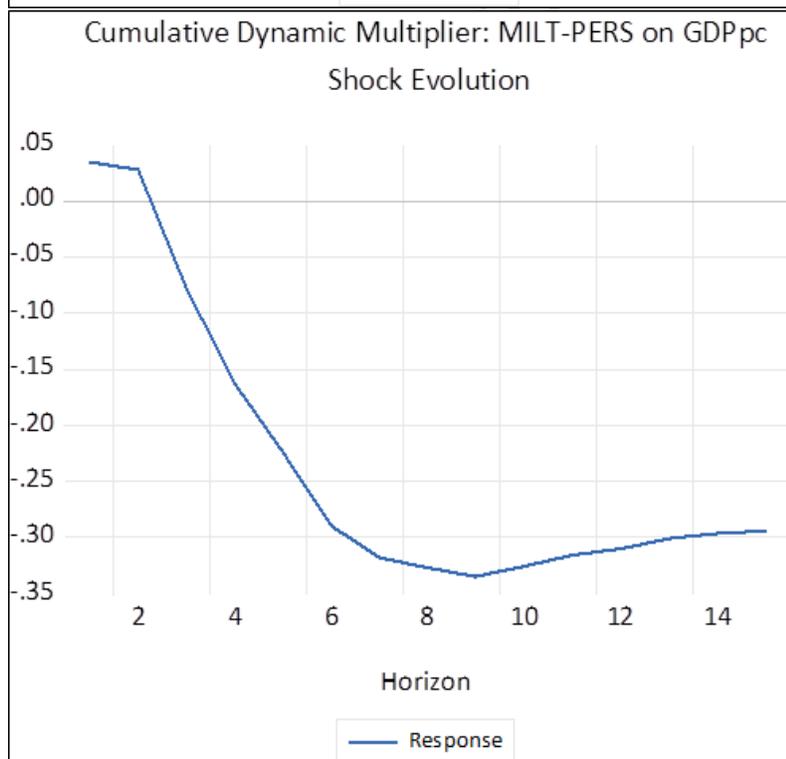
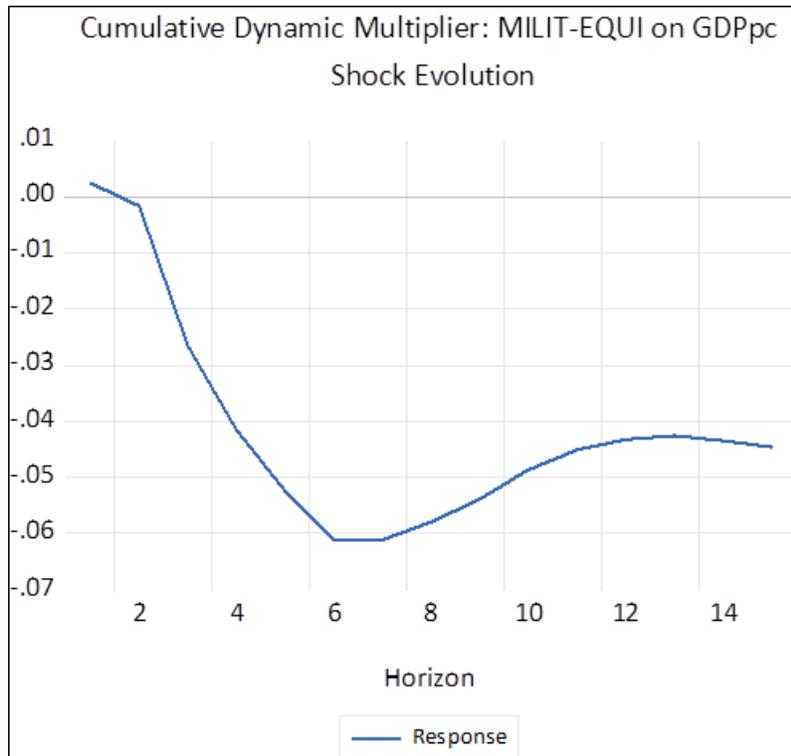


**Model 4.**

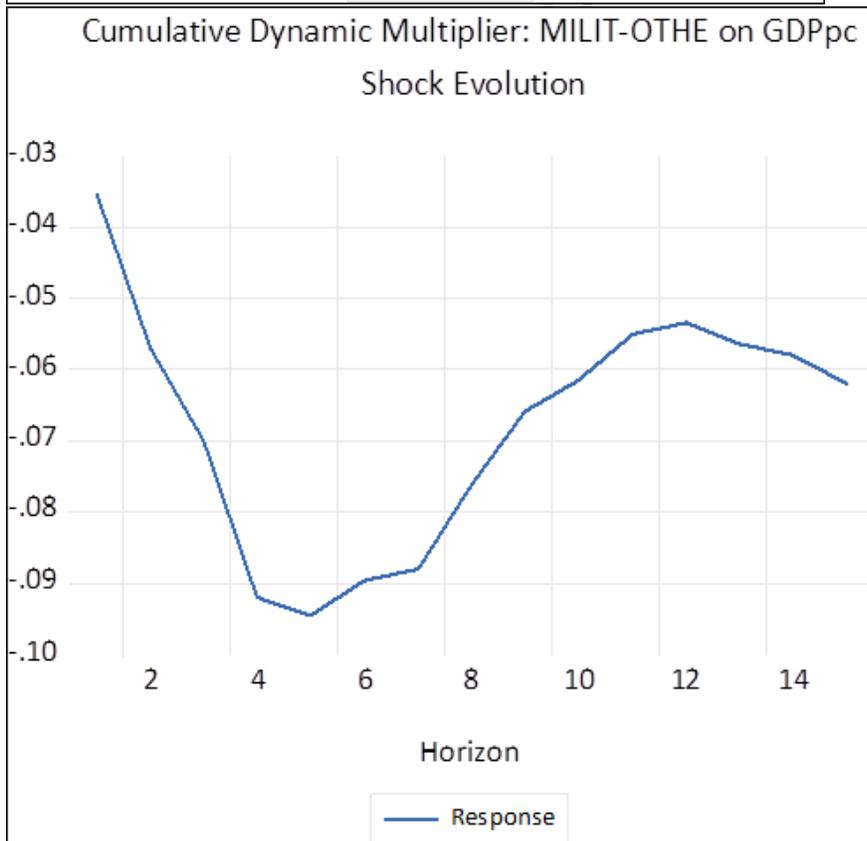
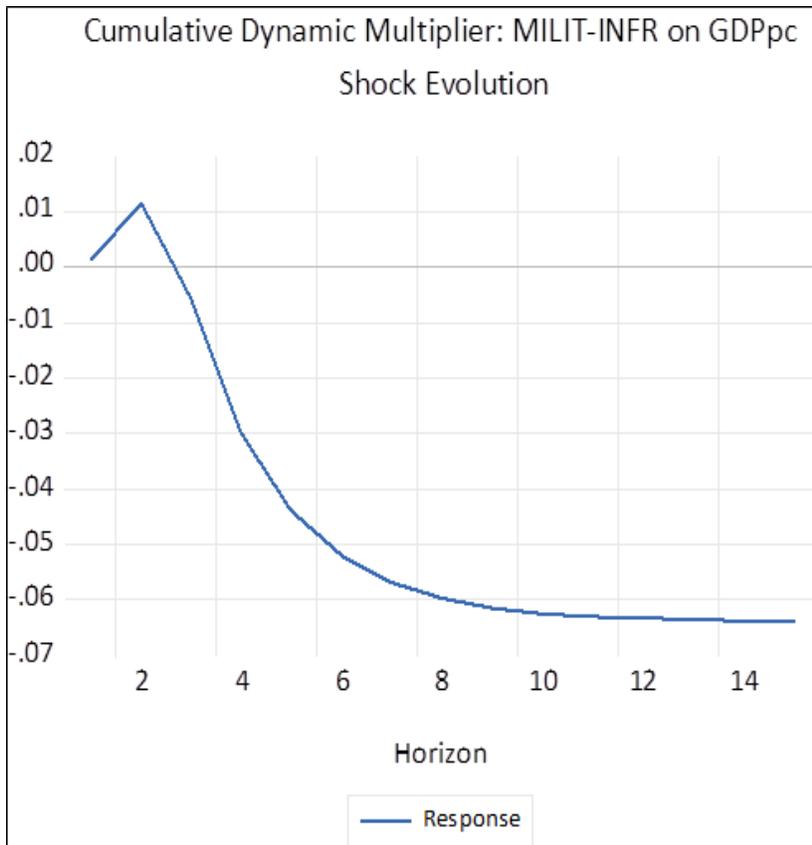
**Model 5.**

**Figures 4a-h. Plots of Dynamic Multipliers**





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**Figure 5. Impulse Response Analysis**

