DEFENCE SPENDING AND ECONOMIC GROWTH:
AN EMPIRICAL INVESTIGATION FOR GREECE AND TURKEY
USING GRANGER ANALYSIS

Abstract

This paper investigates the relationship between the defence spending and economic growth for two adjacent countries, members of NATO, namely Greece and Turkey. Greece, a member-country of European Union, spends more money than other member-countries of EU relatively to its GDP and Turkey has already started accession negotiations with EU in 2004. In the empirical analysis of this paper Johansen cointegration test is applied, using vector error correction model, in order to examine the relationship between defence spending and economic growth. This paper proves that there is no cointegrated relationship between the two variables, while the Granger causality results indicate a unidirectional causal relationship between economic growth and defence spending for both countries. Moreover they indicate that there is a bilateral causal relationship between defences spending of the two countries.

Keywords: defence spending, economic growth, cointegration, Granger causality

JEL. A10, C22.
1. Introduction

Defence spending as an economic variable is analysed in the framework of the classical optimisation problem under limitations in conditions of uncertainty. The main target of every representative government is the provision of some public goods such as protection, security, peace and war prevention. Defence spending is a key leading to this target. It is important to mention that defence spending on capital and mechanical armament, should be considered part of public investment expenditure and not, as it is often mistakenly believed, part of public consumption expenditure. Therefore, each government tries to solve the optimisation problem of the country’s protection (in relation to the defence spending) under some limitations deriving from:

- the current and previous levels of GDP;
- the balance of payments;
- the defence spending of allied countries; and
- the defence spending of opponent countries.

The presence of economic restraints in accordance with GDP and balance payments type is given. Given the environment of incomplete information (uncertainty), the government should decide the growth rate of defence spending. There is an uncertainty for the future state of the economy, the future governments and their relative preferences between political and defence expenditure and also the behaviour and the reaction of allies and opposite countries.

The problem is more complicated due to the uncertainty of the future level of military technology. Most researchers argue that defence spending is changing in accordance with the political placement of the government (conservative or labour) Hartley and Mclean (1978), without taking into account the time and the military technology. This
aspect is not acceptable by many authors, given that all governments are well disposed towards both political parties, which accomplish defence spending. This is confirmed by the statistical data that show clearly that defence-spending changes are in accordance with the production technology and not with the political placement (Antonakis 1987).

In the last few years, there has been a rapid progress in the production technology of conventional weapons, which resulted in output growth and in the change of per unit production cost. Therefore, we expect a positive relationship between defence spending and production technology.

2. Theoretical and empirical approaches

Based on Benoit’s studies (1973) the relationship between defence spending and economic growth has been the subject of extensive empirical work. However, there is much controversy in literature over whether defence spending is associated with higher or lower growth rates. Some researchers argue that the effect of defence spending on economic growth is positive Benoit (1973), but others as Deger (1986), Lipow and Antinori (1995) argue that defence spending has a negative effect on economic growth through what is generally referred to as an investment crowding-out effect, or a displacement of an equal amount of civilian resource use. Alternatively, defence spending may also stimulate economic growth through Keynesian-type aggregate demand effects. An increase in demand generated by higher military spending leads to increased utilization of capital stock, higher employment and profits, and therefore higher investment which further generates short-run multiplier effects.
A third group tends to give context-specific explanations that vary from positive to negative effects (DeRouen 1995, and Landau 1996). All the above studies test the relationship between the two variables by estimating growth functions that include defence spending as an explanatory variable.

Coulomb and Fontanel (2001) argue that the reduced military expenditure encourages long-run world economic growth, but a fair partition of wealth is a condition of peace. When poverty threatens dignity, nations often prefer struggle to status quo. International security cannot be durably maintained under conditions of domination or excessive economic and social inequalities. For advocates of the New International Economic Order, underdevelopment therefore constitutes a threat to world peace and disarmament is a consequence of development.

Recent studies, examining the relationship between economic growth and defence spending, determine the issue of the direction of causation. For example Joerding (1986) tests for Granger causality between defence spending and economic growth on 57 less developing countries (LDCs). There is an empirical evidence of causality running from economic growth to defence spending and not vice versa. Chowdhury (1991), applies Granger causality tests for 55 developing countries. No consensus of results is found. For 15 countries the results indicate that defence spending causes economic growth. Unidirectional Granger causality, running from economic growth to defence spending, is evident in seven countries, while in three countries there is a feedback relationship between these variables.

The statistical methodology used in the above studies limit them to an estimation of some short-run dynamic effects between these two variables and does not permit the estimation of the long-run equilibrium relationships.
Recent advances in time series analysis, cointegration tests, the vector error correction mechanism and common stochastic trends provide more effective techniques to study the long-run equilibrium relationships between the integrated variables. The techniques of cointegration analysis and the causality between economic growth and defence spending have been employed in recent studies by (Aseery 1996, Kollias and Makrydakis 1997 and Sezgin 2001).

Aseery (1996) examines the Granger causality between defence spending and economic growth for Iraq over the period 1950-1980. Firstly, he tests the time series stationarity and then he examines the cointegration of the variables using two methods. Both methods result in the rejection of the null hypothesis where there is no cointegration, while the Granger causality test suggests that defence spending causes economic growth.

Kollias and Makrydakis, (1997), test for Granger causality between growth rates in GDP and the share of military expenditure in GDP for Turkey over the period 1954-1993. Using two dummies in their model due to Cyprus crisis in the mid-1970s, they came up with the conclusion that there is no causal relationship between military expenditure and growth rates in GDP.

Sezgin (2001) analyses the defence-growth relationships in Turkey for the period 1956-1994. After a review of some empirical studies on the defence-growth relationships, a Deger type demand and supply side model is investigated using 2SLS and 3SLS simultaneous equation method. This study concludes that Turkey’s economic growth is stimulated by its defence sector, while defence spending has no significant effect on savings and balance of trade and also that major determinants of Turkish defence spending are its income level, the conflict with PKK (Kurdish Worker’s Party) and Greece’s defence spending.
Dakurah et al (2001), using Granger causality method extended to incorporate non-stationarity and cointegration, evaluate the causal relationships between defence spending and economic growth in 62 developing countries. The results of their paper showed that unidirectional causality was found in 23 countries, from either defence spending to economic growth or vice versa, while bi-directional causality existed in 7 countries. Causality did not exist in 18 countries that were integrated of differing orders.

Brauer (2002) presents a comprehensive critical review of the entire literature in examining the relationship between defence spending and economic growth of Greece and Turkey. In his review, Brauer attempts to analyse:

a) arms race models
b) models of the demand for defence spending
c) models measuring the economic impact of defence spending
d) the literature and issues relating to indigenous arms production
e) theoretical aspects of other researchers for the relationship between defence spending of Greece and Turkey

Final, Brauer presents a critical analysis of the extensive literature on Greek and Turkish defence spending, its politico-military underpinnings and its economic effects.

The large amount of money that Greece and Turkey spend for their defence sector both in absolute and relative terms (percentage of GDP), is an inhibitory factor in the growth process of the two economies. The increase in defence spending can be explained by the strategic factors (existence or threat of war) that appeared in the period 1975-1980 following the events in Cyprus and by the increasing arms race the two countries found themselves in during the post-war period.
While most of the previous studies focused only on a two-variable case and their results may be biased due to the omission of other relevant variables, in this paper, the causal relationship defence spending and economic growth in a trivariate model for Greece and Turkey is investigated using time series data over the period 1960-2001.

This paper has three objectives:

- to determine whether a stationary long-run relationship exists between defence spending and economic growth for Greece and Turkey;
- to examine the causality between these two variables; and
- to test the arm race hypothesis (competitiveness to armament) between the two countries using Granger causality test in a trivariate model.

The remainder of this paper is organized as follows: Section 1 reports the role of defence spending to national security and protection while section 2 describes the theoretical and empirical approaches related to the paper. Section 3 describes the data that have been used in this paper, as well as the specification model. Section 4 estimates the results of the unit root tests and examines the data stationarity. The cointegration analysis among variables is presented in Section 5. Section 6 deploys the Granger causality tests. Section 7 provides the empirical results of the above tests. Finally, section 8 summarises the conclusions of this paper.

3. Data specification of the model

For the analysis of defence spending for both countries the following function has been used:

\[ DS = f (GDP) \]  \hspace{1cm} (1)

where DS expresses the defence spending of the examined countries and GDP is their gross domestic product. The causality types that should be analyzed are the following:
• A unidirectional causality running from defence spending to economic growth (GDP).
• A unidirectional causality running from economic growth (GDP) to defence spending (DS)
• A bidirectional causality between defence spending (DS) and economic growth (GDP).
• No causality between defence spending (DS) and economic growth (GDP).

The hypotheses of model (1) assume that the variables are stationary and since the stationarity has been ascertained, the cointegration and causality tests are applied. However, it should be noted that there are some other factors which affect the relationship between defence spending and economic growth such as balance of goods, services, and incomes, educational expenditures, health expenditures, social expenditures, civil expenditures.

The data that have been used in this analysis are annual, covering the period 1960-2001 regarding 1990 as a base year. All variables are measured in million dollars and are expressed by logarithms in order to include the proliferative effect of time series and are symbolized with the letter L preceding each variable name. The databases for Greece and Turkey are Yearbook of International Financial Statistics (IMF), and Stockholm International Peace Research Institute (SIPRI). The list of variables that have been used in the analysis of defence spending for the two countries are:

LDSGR = Logarithm of Defence Spending of Greece.
LDSTR = Logarithm of Defence Spending of Turkey.
LGDPGR = Logarithm of Gross Domestic Product of Greece.
LGDPTR = Logarithm of Gross Domestic Product of Turkey.
4. Unit root tests

Many macroeconomic time series contain unit roots dominated by stochastic trends as developed by Nelson and Plosser (1982). Unit roots are important in examining the stationarity of a time series because a non-stationary regressor invalidates many standard empirical results. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. In this study a unit root test is tested using Augmented Dickey-Fuller (ADF), Phillips-Perron and Kwiatkowski et al.

4.1 Augmented Dickey-Fuller (ADF test)

The augmented Dickey-Fuller test (1979) is referred to the t-statistic of $\delta_2$ coefficient on the following regression:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t$$

(2)

The ADF regression tests for the existence of unit root of $X_t$, namely in the logarithm of all model variables at time $t$. The variable $\Delta X_{t,i}$ expresses the first differences with $k$ lags and finally $u_t$ is the variable that adjusts the errors of autocorrelation. The coefficients $\delta_0$, $\delta_1$, $\delta_2$, and $\alpha_i$ are being estimated. The null and the alternative hypothesis for the existence of unit root in variable $X_t$ is:

$$H_0 : \delta_2 = 0 \quad H_\mu : \delta_2 < 0$$

This paper follows the suggestion of Engle and Yoo (1987) using the Akaike information criterion (AIC) (1974), to determine the optimal specification of Equation
(2). The appropriate order of the model is determined by computing Equation (2) over a selected grid of values of the number of lags k and finding that value of k at which the AIC attains its minimum. The distribution of the ADF statistic is non-standard and the critical values tabulated by Mackinnon (1991) are used.

4.2 Phillips-Perron (PP test)

Phillips-Perron (1988) test is an extension of the Dickey-Fuller test, which makes the semi-parametric correction for autocorrelation and is more robust in the case of weakly autocorrelation and heteroskedastic regression residuals. According to Choi (1992), the Phillips-Perron test appears to be more powerful than the ADF test for the aggregate data.

4.3 Kwiatkowski, Phillips, Schmidt, and Shin’s (KPSS test)

Since the null hypothesis in Augmented Dickey-Fuller test is that a time series contains a unit root, this hypothesis is accepted unless there is a strong evidence against it. However, this approach may have low power against stationary near unit root processes. In contrast Kwiatkowski et al (1992) present a test where the null hypothesis is that a series is stationary. The KPSS test complements the Augmented Dickey-Fuller test in that it regards the power of either test can be addressed by comparing the significance of statistics from both tests. A stationary series has significant Augmented Dickey-Fuller statistics and insignificant KPSS\(^1\) statistics.

\(^1\) According to Kwiatkowski et al (1992), the test of KPSS assumes that a time series can be composed into three components, a deterministic time trend, a random walk and a stationary error:

\[ y_t = \delta t + r_t + \epsilon_t \]
5. Cointegration test

If the time series (variables) are non-stationary in their levels, they can be integrated with integration of order 1, when their first differences are stationary. These variables can be cointegrated as well, if there are one or more linear combinations among the variables that are stationary. If these variables are being cointegrated, then there is a constant long-run linear relationship among them.

Since it has been determined that the variables under examination are integrated of order 1 for both two countries, then the cointegration test is performed. The testing hypothesis is the null of non-cointegration against the alternative that is the existence

where \( r_t \) is a random walk: \( r_t = r_{t-1} + u_t \). The \( u_t \) is iid \( (0, \sigma^2_u) \).

The stationary hypothesis implies that \( \sigma^2_u = 0 \).

Under the null, \( y_t \) is stationary around a constant (\( \delta = 0 \)) or trend-stationary (\( \delta \neq 0 \)). In practice, one simply runs a regression of \( y_t \) over a constant (in the case of level-stationarity) or a constant plus a time trend (in the case of trend-stationary). Using the residuals, \( e_t \), from this regression, one computes the LM statistic

\[
LM = T^{-2} \sum_{t=1}^{T} S_t^2 / S_u^2
\]

where \( S_u^2 \) is the estimate of variance of \( e_t \)

\[
S_t = \sum_{i=1}^{T} e_t^2, \quad t = 1,2,\ldots,T
\]

The distribution of LM is non-standard: the test is an upper tail test and limiting values are provided by Kwiatkowski et al (1992), via Monte Carlo simulation. To allow weaker assumptions about the behavior of \( e_t \), one can rely, following Phillips and Perron (1988) on the Newey and West (1987) estimate of the long-run variance of \( e_t \) which is defined as:

\[
S^2(l) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} e_t e_{t-k}
\]

where \( w(s,l) = 1 - s / (l+1) \). In this case the test becomes

\[
\nu = T^{-2} \sum_{t=1}^{T} S_t^2 / S^2(l)
\]

which is the one considered here. Obviously the value of the test will depend upon the choice of the ‘lag truncation parameter’, \( l \). Here we use the sample autocorrelation function of \( \Delta e_t \) to determine the maximum value of the lag length \( l \).
of cointegration. Following the maximum likelihood procedure of Johansen (1988) and Johansen and Juselious (1990), a $p$-dimensional ($p \times 1$) vector autoregressive model with Gaussian errors can be expressed by its first-differenced error correction form as:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-p} + u_t \quad (3)$$

where:

$Y_t$ is a $p \times 1$ vector containing the variables.
$
\mu$ is the $p \times 1$ vector of constant terms.

$\Gamma_i = -I + A_1 + A_2 + \ldots + A_i$ ($i = 1, 2, \ldots, p-1$) is the $p \times p$ matrix of coefficients.

$\Pi = I - A_1 - A_2 - \ldots - A_p$ is the $p \times p$ matrix of coefficients.

$u_t$ is the $p \times 1$ vector of the disturbance terms coefficients.

The $\Pi$ matrix conveys information about the long-run relationship between $Y_t$ variables and the rank of $\Pi$ is the number of linearly independent and stationary linear combinations of the variables studied. Thus, testing for cointegration involves testing for the rank of $\Pi$ matrix $r$ by examining whether the eigenvalues of $\Pi$ are significantly different from zero. Johansen (1988) and Johansen and Juselious (1990) propose two test statistics for testing the number of cointegrating vectors (or the rank of $\Pi$) in the VAR model. These are the trace (Tr) test and the maximum eigenvalue ($L$-max) test. The likelihood ratio statistic for the trace test is:
\[-2 \ln Q = -T \sum_{j=r+1}^{p} \ln(1 - \hat{\lambda}_j) \quad (4)\]

where \( \hat{\lambda}_{r+1}, \ldots, \hat{\lambda}_p \) are the estimated \( p - r \) smallest eigenvalues. The null hypothesis to be tested is that there are at most \( r \) cointegrating vectors. That is, the number of cointegrating vectors is less than or equal to \( r \), where \( r \) is 0, 1, or 2, and so forth. In each case, the null hypothesis is tested against the general alternative.

Alternatively, the \( L\text{-}max \) statistic is:

\[-2 \ln Q = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (5)\]

In this test, the null hypothesis of \( r \) cointegrating vectors is tested against the alternative hypothesis of \( r+1 \) cointegrating vectors. Thus, the null hypothesis \( r = 0 \) is tested against the alternative that \( r = 1 \), \( r = 1 \) against the alternative \( r = 2 \), and so forth. It is well known that the cointegration tests are very sensitive to the choice of lag length. The Schwartz Criterion (SC) and the likelihood ratio test are used to select the number of lags required in the cointegration test.

6. Granger causality test

If there exists a cointegration vector between defence spending and economic growth, there is causality among these variable at least in one direction (see Granger 1988). Thus, Granger causality tests can be used to examine the nature of the relationship. Granger (1986) and Engle and Granger (1987) provide a test of causality, which takes into account the information, provided by the cointegrated properties of variables. The
model can be expressed as an error correction model (ECM) as follows (see Engle and Granger, 1987):

\[
\Delta Y_t = \sum_{i=1}^{m} \alpha_i \Delta Y_{1,t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{2,t-1} + \sum_{i=1}^{m} \gamma_i \Delta Y_{3,t-1} + \delta \Delta Z_{t-1} + \mu_t + \varepsilon_t
\]  
(6)

where \(Y_t\) denotes either gross domestic product for Greece or defence spending for both countries.

\(\delta \Delta Z_{t-1}\) contains cointegrating terms, reflecting the long-run equilibrium relationship among variables.

From the model (6), the Granger causality tests are examined by testing whether all the coefficients of \(\Delta Y_{2,t-1}\) or \(\Delta Y_{3,t-1}\) are statistically significant as a group (based on a standard F-test) and whether the \(\delta\) coefficient of the error correction term is also statistically significant.

From equation 6, it is possible to test whether there exist arm races between the two examined countries and whether the causal relationship between defence spending of the two countries is bilateral (see, Kollias and Makrydakis 1997).

Since the Granger causality tests are very sensitive to the lag length selection. In this paper the lag lengths are determined using Hsiao’s (1979, 1981) sequential procedure which is based on the Granger definition of causality and Akaike’s (1969) minimum final prediction error (FPE) criterion.

7. Empirical results

7.1 Unit root tests
Table 1 reports the results of the ADF, PP, KPSS tests for the variables of economic growth and defence spending of the two countries in the levels and their first differences. The ADF statistic suggests that all variables are stationary in their first differences for both countries. Although the Phillips-Perron test gives different lag profiles for the examined variables (time series) and sometimes in lower levels of significance, the main conclusion is qualitatively the same as reported by the Dickey-Fuller (ADF) test. The KPSS statistic tests for lag-truncation parameter one (\(\lambda=1\)), (since it is unknown how many lagged residuals should be used to construct a consistent estimator of the residual variance), rejects the null hypothesis in the levels of the examined variables for this lag-truncation parameter (\(\lambda=1\)). Therefore the combined results (ADF, PP, KPSS) from all tests can be characterized as integrated of order one, I(1).

7.2 Cointegration tests

Since it has been determined that the variables under examination are integrated of order 1, then the cointegration test is performed. The testing hypothesis is the null of non-cointegration against the alternative that is the existence of cointegration using the Johansen (1988) maximum likelihood procedure. A VAR model is fitted to the data to find an appropriate lag structure. The Schwartz Criterion (SC) and the likelihood ratio test also suggest two lags for the examined countries. Table 2 presents the results from the Johansen cointegration tests. Trace statistics and L-max statistic (eigenvalue) suggest that there exists no cointegrating relationship between economic...
growth and defence spending of the two countries. Therefore, there is no long-run relationship between these variables.

Then we examine the cointegrating relationship between the three variables, namely the defence spending and economic growth of Greece, the defence spending of Turkey, the defence spending and economic growth of Turkey, and finally the defence spending of Greece. The results of the cointegration test in the two-trivariate systems for both countries appear in the same Table.

From the results of Table 2 we can infer that there is no cointegrating relationship not even between the two-trivariate systems. Consequently, there is no long run relationship between these three variables.

**INSERT TABLE 2 APPROXIMATELY HERE**

### 7.3 Causality test results

Given the results of the cointegration tests, the causality tests are conducted by running the standard Granger regressions of equation (6). Since the definition of causality refers to predictability, Hsiao (1981) proposes a stepwise Granger causality technique using Akaike’s minimum final prediction error FPE criterion to select the optimum lag length. Table 3 presents the Granger causality tests for both countries using Hsiao technique. The numbers in the brackets indicate the lag length selected by using the FPE criterion. From the results of Table 3 we can infer that there is a unidirectional causal relationship running from economic growth to defence spending.

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2 This procedure is known as the stepwise Granger- causality technique, which provides statistical criteria for choosing the optimum lag length using past information. The FPE criterion is specified as follows:

\[
FPE = \left( \frac{T+k}{T-k} \right)^* \frac{SSR}{T}
\]

where T is the number of observations, k is the number of parameters estimated, and SSR is the sum of squared residuals.
for both countries. This result is not consistent with those found in Kollias and Makrydakis (1997a), which suggested that there is no causal relationship between defence spending and economic growth of Turkey, and also it is not consistent with the results found by Dunne, Nikolaidou and Vougas (1998), which suggested that there is a unidirectional causal relationship between defence spending and economic growth running from defence spending to economic growth for both countries. Joerding (1986) and Chowdhurry (1991) indicated that economic growth causes prior to defence spending. Therefore, although defence spending may affect economic growth through several channels such as the Keynesian-type aggregate demand effect, it is also plausible that economic growth may be causally prior to defence spending. The Granger causality results further imply that defence spending is a strong exogenous variable relative to economic growth for both countries. The bilateral causal relationship between defence spending of both countries indicates that arm races exist between them (that was proved in 1974 when there was a tension between the two countries as far as the Cyprus issue is concerned). This result is consistent with those found in Kollias and Paleologou (2002), while in Georgiou, Kapopoulos and Lazaretou (1996) this relationship is unidirectional running from defence spending of Greece to defence spending of Turkey.

INSERT TABLE 3 APPROXIMATELY HERE
8. Conclusions

The relationship between Greece and Turkey has gone through periods of peaceful coexistence and also periods of strong competitiveness and conflicts. Defence spending from both countries is a representative indicator of historical fluctuations in their bilateral relations. The Greek-Turkish armament has drawn the attention of many researchers in the field of economics’ defence.

Understanding the time series dynamics between economic growth and defence spending has received much attention in the recent literature. More specifically, in a number of studies, it has been attempted to analyse the empirical-econometric aspect of these countries’ armament rivalry and there has been significant differences in the overall results. This paper does not examine only the causal relationship between these two variables, but also examines a (VAR) vector autoregressive model including the defence spending of both countries, taking into account the hypothesis of competition in an armament race between these two countries.

The results of this paper showed that there is no cointegrated relationship for the examined variables of the two countries. Consequently, there is no long-run relationship between economic growth and defence spending for both countries, and between defence spending of the two countries as well.

Also, the Granger causality tests suggest that there is a unidirectional causal relationship between economic growth and defence spending for both countries running from economic growth to defence spending implying that economic growth is prior to defence spending (defence spending follows economic growth). Finally, there is a bilateral causality between defence spending of both countries implying that arm races exist (armament competitiveness) between these two countries. This result was
predictable because Greek and Turkish defence spending affect each other on a large scale mainly after the period of Turkish invasion in Cyprus in 1974 and the bilateral dispute which was and is still regarded as the main reason for the Greek - Turkish defence spending during the last years. Moreover, the result of the bidirectional causal relation between these two countries shows that Greek and Turkish defence spending is not autonomous, but its size depends on the size of the Turkish (Greek) defence spending. In other words, those who exercise defence policy, determine the level of defence spending of their own country according to the level of defence spending of the other country.

From a methodological perspective, this study can also be extended to a more generalized multivariate system, where economic growth and defence spending are exposed to influences by other economic factors such as foreign aid, net capital inflow and other non-economic factors as well as by the use of deterministic dummies. All these factors, in conjunction with other economic ones, can affect defence spending in one country and represent an important parameter, which can overshadow the fundamental relationship between the examined variables and can encumber the investigation of the causal relationship that may exist.

More specifically, such factors in the case of the Greek-Turkish arms race are the wider geopolitical instability that has existed during the last years in the whole region and which increases the problems of foreign security for both countries, the unstable bilateral relations with other countries apart from the examined ones such as Iran, Iraq, Bulgaria, etc., the obligations stemming from NATO alliance participation, the increased defensive needs during the Cold War period and the Kurdish problem in the Turkish South-Eastern borders that for many years remained an important security problem. Future studies may be needed in this direction.
References


## Table 1. Tests of unit roots hypothesis

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<thead>
<tr>
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<th>Augmented Dickey-Fuller</th>
<th>Phillips-Perron</th>
<th>KPSS</th>
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<tbody>
<tr>
<td></td>
<td>$\tau_\mu$</td>
<td>$\tau_\nu$</td>
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<tr>
<td></td>
<td>$\eta_0$</td>
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<td>-3.23*</td>
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</table>

Notes: $\tau_\mu$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is not included in equation 2 and $\tau_\nu$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is included in equation 2. The calculated statistics are those reported in Dickey-Fuller (1981). The critical values at 1%, 5% and 10% are –3.61, -2.94 and –2.60 for $\tau_\mu$ and –4.21, -3.53 and –3.19 for $\tau_\nu$ respectively.

The lag-length structure of a $\chi$ of the dependent variable $x_t$ is determined using the recursive procedure in the light of a Langrange multiplier (LM) autocorrelation test (for orders up to four), which is asymptotically distributed as chi-squared distribution and the value t-statistic of the coefficient associated with the last lag in the estimated autoregression.

The critical values for the Phillips-Perron unit root tests are obtained from Dickey-Fuller (1981). $\eta_0$ and $\eta_r$ are the KPSS statistics for testing the null hypothesis that the series are I(0) when the residuals are computed from a regression equation with only an intercept and intercept and time trend, respectively. The critical values at 1%, 5% and 10% are 0.739, 0.463 and 0.347 for $\eta_0$ and 0.216, 0.146 and 0.119 for $\eta_r$ respectively (Kwiatkowski et al, 1992, table 1).

Since the value of the test will depend upon the choice of the ‘lag truncation parameter’, $l$. Here we use the sample autocorrelation function of $\Delta x_t$ to determine the maximum value of the lag length $l$.

***, **, * indicate significance at the 1, 5 and 10 percentage levels.
Table 2. Cointegration test results for Greece and Turkey data series

<table>
<thead>
<tr>
<th></th>
<th>Trace</th>
<th>L-max</th>
<th>Trace (5%) Critical value</th>
<th>Trace (1%) Critical value</th>
<th>L-max (5%) Critical value</th>
<th>L-max (1%) Critical value</th>
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<tr>
<td>LGDPGR and LDSGR</td>
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<tr>
<td>(VAR lag=2)</td>
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<tr>
<td>H₀: r = 0</td>
<td>11.27</td>
<td>10.32</td>
<td>15.41</td>
<td>20.04</td>
<td>14.07</td>
<td>18.63</td>
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<tr>
<td>H₀: r ≤ 1</td>
<td>2.44</td>
<td>2.44</td>
<td>3.76</td>
<td>6.65</td>
<td>3.76</td>
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<td><strong>TURKEY</strong></td>
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<td>LGDPTR and LDSTR</td>
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<td>(VAR lag=2)</td>
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<tr>
<td>H₀: r = 0</td>
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<td>9.73</td>
<td>15.41</td>
<td>20.04</td>
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<td>H₀: r ≤ 1</td>
<td>3.55</td>
<td>3.55</td>
<td>3.76</td>
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<td>3.76</td>
<td>6.65</td>
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<tr>
<td>H₀: r = 0</td>
<td>5.61</td>
<td>5.58</td>
<td>15.41</td>
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<tr>
<td>H₀: r ≤ 1</td>
<td>0.03</td>
<td>0.03</td>
<td>3.76</td>
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<td>LDSGR, LDSTR and LGDPGR</td>
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<tr>
<td>H₀: r = 0</td>
<td>14.36</td>
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<td>29.68</td>
<td>35.65</td>
<td>20.97</td>
<td>25.52</td>
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<tr>
<td>H₀: r ≤ 1</td>
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<td>10.39</td>
<td>15.41</td>
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<td>18.63</td>
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<td>H₀: r ≤ 2</td>
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<td>3.76</td>
<td>6.65</td>
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<td>LDSTR, LDSGR, and LGDPTR</td>
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<td>(VAR lag=2)</td>
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<tr>
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<td>12.15</td>
<td>10.98</td>
<td>29.68</td>
<td>35.65</td>
<td>20.97</td>
<td>25.52</td>
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<tr>
<td>H₀: r ≤ 1</td>
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<td>4.93</td>
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<tr>
<td>H₀: r ≤ 2</td>
<td>0.09</td>
<td>0.09</td>
<td>3.76</td>
<td>6.65</td>
<td>3.76</td>
<td>6.65</td>
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</table>

Notes: Schwartz criteria (SC) and the likelihood ratio tests are used to select the number of lags required in the cointegrating test. r denotes the number of cointegrating vectors.
Table 3. Granger causality test

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>F – significance level</th>
<th>t – statistic $Z_{t-1}$</th>
<th>Causality analysis</th>
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<tbody>
<tr>
<td></td>
<td>$\Delta LGDPGR$</td>
<td>$\Delta LDSGR$</td>
<td>$\Delta LGDPTR$</td>
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<tr>
<td><strong>GREECE</strong></td>
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<td>$\Delta LGDPGR$</td>
<td>0.105[1]</td>
<td>0.089[1]</td>
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<tr>
<td>$\Delta LDSGR$</td>
<td>0.219[2]</td>
<td>0.313[2]</td>
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<tr>
<td>$LGDPGR \Rightarrow LDSGR$</td>
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<tr>
<td><strong>TURKEY</strong></td>
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<tr>
<td>$\Delta LGDPTR$</td>
<td>0.052[1]</td>
<td>0.322[1]</td>
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<td>$\Delta LDSTR$</td>
<td>0.494[1]</td>
<td>0.571[1]</td>
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<td>0.000[1]</td>
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<tr>
<td>$\Delta LDSTR$</td>
<td>0.003[1]</td>
<td>0.042[1]</td>
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<tr>
<td>$LDSTR \Leftrightarrow LDSGR$</td>
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</tbody>
</table>

Notes: The number in the brackets indicates the lag length selected by using the FPE criterion.