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ASSESSING THE IMPACT OF MILITARY EXPENDITURE ON ECONOMIC GROWTH: A LONGITUDINAL ANALYSIS OF GREECE, 1958-93

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Abstract

Earlier empirical studies on the growth effects of military expenditure have reported conflicting research findings, attributable to the use of cross-sectional data and differences in the specification of the estimated models, definitions of the variables and estimation techniques used. Moreover, to the extent that countries differ substantially in resources and socioeconomic structures, it is reasonable to expect differences in both the intensity and the direction of the growth effects of military spending among various regions of the world. These considerations point to the need for case specific studies using time-series data for individual countries. In this context, the present study seeks to contribute to current research in the area by investigating the growth-defence relationship in the case of Greece over the period 1958-93. Basically, military expenditure may affect economic growth through the creation of aggregate demand, the possible reduction of investment, the defence spin-offs and the crowding-out of the work force. Those influences can be captured by a growth-defence relationship based on the two-sector neoclassical production-function framework, which allows the level of activity in one sector to act as an externality in another sector and also permits marginal factor productivities to vary between the two sectors. Using the technique of cointegration and the related notion of error correction, the paper reports findings that lend support to the hypothesis that military expenditure retards the output growth rates in Greece, contrary to the inconclusive findings of previous studies.

Keywords: Military expenditure, economic growth, cointegration. JEL Classification: H56, C32

1. Introduction

The seminal work of Benoit (1973, 1978) stimulated a great deal of interest in the question of how military expenditure affects economic growth. During the last few years the literature on the subject has been growing fast producing conflicting research findings. While Benoit himself and a number of other studies have claimed that military expenditure may be conducive to economic growth (Kennedy, 1974; Dixon and Moon, 1986; Alexander, 1995), others have reported that such spending is detrimental to growth (Deger and Sen, 1983; Deger and Smith, 1983; Leontief and Duchin, 1983; Lim, 1983; Faini, Annez and Taylor, 1984; Deger, 1986a; Gyimah-Brempong, 1989). Furthermore, a third set of studies have concluded either that military expenditure promotes economic growth in resource-rich but not in resource-constrained countries (Frederiksen and Looney, 1982, 1983; Looney and Frederiksen, 1986), or that it neither promotes nor impedes growth to any significant extent (Biswas and Ram, 1986; Hess, 1989; Alexander, 1990). These studies have utilized cross-sectional data and their conflicting results should be attributed to differences in the specification of the estimated models, definitions of the variables, samples chosen and estimation techniques used[1].

One shortcoming of the use of cross-sectional data for the estimation of growth-defence relationships is the implicit assumption of structural stability across the countries of the sample. However, to the extent that countries differ substantially in resources and socioeconomic structures, it is inappropriate to assume that the same empirical relationship holds for all countries. In other words, as Deger (1986b) and Kusi (1994) point out, the effects of military expenditure cannot be generalized across countries. Chowdhury's (1991) results of Granger causality tests suggest that the growth- defence relationship is not uniform across countries, while Cappelen, Gleditsch and Bjerkholt (1984) have shown that differences exist in both the intensity and the direction of the growth effects of military spending among 17 OECD countries.

The fact that the growth effects of military expenditure evidently differ among countries points to the need, as Grobar and Porter (1989) argue, for case specific studies using time-series data for individual countries. While cross-section analysis is asking if empirical regularities exist among countries and provides general conclusions on long-term effects, time-series analysis is more relevant in investigating short-term effects for policy purposes and decision making in a national setting. Thus, it is not surprising to observe that the number of such country specific studies has been growing in recent years[2]. In this context, the present study seeks to contribute to current research in the area by investigating the growth-defence relationship in the case of Greece during the post-war period. Greece is chosen for empirical work mainly for two reasons. First, it has constantly ranked among the countries with the highest defence burden (military expenditure as a share of GDP) in NATO and in Europe. Thus, in the period 1970-94 Greece allocated an average of 5.8% of GDP to defence compared to a NATO average of 3.3%[3]. Secondly, the Greek economy is one of the weakest in Europe with persistent and chronic economic problems[4]. During the period 1980-95 the average annual growth rates of Greek GDP, industrial production and gross fixed capital formation were 1.3%, 0.5% and -0.4% compared to the respective averages of 2%, 1.2% and 1.5% for the European Union. Also, in 1995 Greek GDP per capita was equal to 45.4% of the EU average, a figure considerably lower than that of 1981 (52.8%), 1971 (58.2%) or even 1961 (49.1%)[5]. The above considerations suggest that the poor performance rates of the Greek economy might be at least partially attributed to high levels of military expenditure.

Despite its undisputed importance, the question of the growth effects of military expenditure in Greece has not yet attracted a considerable amount of theoretical and empirical research. A number of authors have attempted to handle indirectly the growth-defence relationship either by identifying actual substitutes of military expenditure or by estimating separately the impact of such expenditure on certain measures of economic performance. Thus, Antonakis and Karavidas (1990a,b) estimated single equation models for the periods 1950-85 and 1958-86 and provided evidence of the negative relationship between military spending and the expenditure on private and government investment, health, social and educational services as well as the government civil programmes. Kollias (1994a) and Chletsos and Kollias (1995) estimated single regression models for the periods 1963-90 and 1974-90 and found that military expenditure can have stimulative effects on aggregate demand though it adversely affects investment and savings. Finally, Balfoussias and Stavrinos (1996) estimated a simultaneous equation model for the period 1960-92 and were led to the conclusion that a reallocation of government resources from the defence sector toward civilian purposes would lead to a greater employment level, a higher domestic output and an improvement in the balance of payments.

Evidently, the studies conducted so far have reported findings that can be deemed inconclusive. Apart from the fact that they have not produced a comprehensive model for growth, they have analysed relationships that do not derive from any coherent theory but simply from an ad hoc justification of the variables used. A clearer understanding of the growth-defence relationship in Greece demands a model fairly well grounded in a theoretical framework and capable of producing explicit results for the size and direction of the connection between military expenditure and output growth rates. The research methodology proposed and adopted, hereby, in this paper is based on the two-sector neoclassical production-function framework, which allows the level of activity in one sector to act as an externality in another sector and also permits marginal factor productivities to vary between the two sectors. This approach provides a formal rationalization for the incorporation of military expenditure in a growth equation. However, while economic theory suggests possible equilibrium relationships between variables of interest, it tends to inform us very little with the respect to the adjustment processes at work. For this reason we decided to test the growth-defence relationship in Greece utilizing the technique of cointegration and the related notion of error correction to evaluate the long-term determinants of the output growth rates in Greece and to examine the short-term dynamics.

The rest of the paper is organized as follows. Section 2 identifies the major conduits through which military expenditure affects growth. Section 3 deals with the specification of a neoclassical growth-defence relationship. Section 4 lays out the specifics of the econometric technique deployed and discusses the outcome of the empirical investigation. Section 5 presents some concluding remarks.

2. Main economic effects of military expenditure

The conflicting results of empirical studies conducted upon the growth-defence relationship suggest that econometric analysis appears to be relatively incapable of providing undisputable information on the presense of a negative or positive relationship.. As Fontanel (1994) points out, the ultimate effect of military expenditure on economic growth depends both on the functional combination of several parameters concerned with its causal variables and on the content of growth. However, most researchers consider that the effects of military expenditure on economic growth are transmitted through four main channels, namely the creation of aggregate demand, the possible reduction of investment, the broad spectrum of spin-offs that the military might provide for economic growth and the crowding-out effects of the workforce. The main theoretical issues surrounding the growth effects of military expenditure are reviewed below[6].

From the perspective of Keynesian economics, military spending, as a component of government consumption, promotes economic growth by increasing demand for goods and services. If aggregate demand is initially inadequate relative to potential supply, the extra demand generated by the defence sector may be met by increased utilization of capital stock as well as by greater employment of labour (Benoit, 1973; Smith and Smith, 1980; Faini, Annez and

Taylor, 1984; Scheetz, 1991). Not only will there be short-run multiplier effects, but there will also be the possibility of long-term growth. If producers have idle installed capacity due to the lack of demand, they are not achieving the profit rate that they should get by a more effective utilization of capital. An increase in demand that leads to more efficient capacity utilization may lead to an increase in the profit rate, which will stimulate investment and ultimately increase the growth rate (Deger, 1986a).

Critics of this view object to the assumed existence of slack resources that would otherwise be left idle if not for the demands associated with military spending. Instead, they argue, military spending diverts scarce resources from the civilian sector of the economy where they could be put to more productive use. Many econometric studies tend to provide empirical confirmation of this hypothesis (Smith, 1977, 1980; DeGrasse, 1983; Deger, 1986b) giving at least three explanations for it. First, increases in military expenditure cause excess demand pressures in capital-goods industries whose capacity is relatively inelastic, at least in the short-run. Since military demand is unlikely to be very price-elastic and given the prevalence of cost-plus contracts, the adjustment is usually taken by investment. This happens both through delays in the delivery of equipment and price changes that influence the cost of capital goods and thus investment demand. Under those conditions, military expenditure creates bottlenecks that reduce the possibilities of investment and cause inflationary trends (Gansler, 1982). Secondly, the taxes required to finance military expenditure depress private demand and reduce the anticipated profit from investment. Also, possible debts connected with the financing of the defence effort result in increased interest rates and are therefore conducive to a cutting back of private investment (Findlay and Parker, 1992). Thirdly, given the balance of class forces, the sum of private and civil government consumption tends to be a fairly stable share of potential output. Since the remainder is divided between investment and military expenditure, the effect of a more intensive defence effort is lower investment (Smith, 1977). Furthermore, if new technology is embodied in machines of the latest vintage, then the growth-depressing effects through lower investment are exacerbated (Deger, 1986a).

However, as Benoit (1978) claims, the military itself might, through R&D, introduce new technology in the civilian sector. This is but one of a whole host of indirect effects that defence might have on the rest of the economy. This approach has been widely debated since the development of technology in the defence sector would not have wide application in the civilian sector despite an occasional spill-over (Russett, 1970; De Grasse, 1983; Melman, 1983, 1985). Other spin-off effects of defence that have been emphasized in the literature include the organization of rural labour to accept industrial-type discipline, the provision of educational training and medical care and the creation of infrastructure.

Finally, conflicting results have been reported in the literature in regard to the employment effects of military expenditure. Some researchers have considered that military spending tends to have a negative effect on employment (Boulding, 1970; Szymanski, 1973; DeGrasse, 1983), others have reported that a drastic reduction in military expenditure inevitably leads to increased unemployment (Aben, 1981; Richards, 1991), while Dunne and Smith (1990) have concluded for the United States, the United Kingdom and 11 OECD countries that the unemployment rate was not significantly affected by the proportion of the national product devoted to military uses. However, it remains true that if disarmament applies mainly to personnel costs, the effect on unemployment is liable to be negative, whereas an increase in military capital expenditure would not have a positive effect (Fontanel, 1994)[7].

3. The model

In this paper, the growth effects of military expenditure in Greece are examined in the context of a supply side analysis of changes in aggregate output. Extending the conventional neoclassical framework, where output growth is related to changes in labour and capital through an underlying aggregate production function (Hagen and Hawrylyshyn, 1969; Robinson, 1971), this approach provides a formal rationalization for the incorporation of military expenditure in a growth equation. Such models have been developed by Feder (1982) for the examination of the role of exports in economic growth and, more recently, by Ram (1986) for the investigation of the impact of the government sector on economic growth, and by Biswas and Ram (1986), Atesoglu and Mueller (1990), Mintz and Huang (1990, 1991), Alexander (1990, 1995), Linden (1992) and Heo (1996) for the specification of the economic growth-military expenditure relationship.

Suppose that the economy is made up of two discrete sectors-civilian and defence, and that each of the two sectors' output is a function of capital and labour allocated to the sector. In addition, the defence sector can be thought of as affecting the output of the civilian sector, positively or negatively. Positive effects may include the stimulation and creation of effective demand as well as technological advances and skilled labour that would cost the civilian sector in the absence of government spending on defence sector research and training. Negative effects could be caused by a lack of investment funds due to high tax and interest rates driven by revenue needs of the defence sector, and paucity of research scientists working on defence research with no civilian applications. In general, all these types of influences are outside the control of the civilian sector and are best described as external effects. Thus, the basic production functions can be written as

$$M = M(L_m, K_m) \quad (1)$$

and

$$C = C(L_c, K_c, M) \quad (2)$$

where M is the output of the defence sector or military expenditure[8], C is the output of the civilian sector or GDP net of military expenditure, and the lower-case subscripts denote the sectoral inputs of labour and capital. In equation (1), the entire amount of military expenditure is used in the production function of the defence sector and not the portion of expenditure satisfied by domestic production, for two reasons: First, the two components, M and C, must add up to the aggregate domestic demand of the economy which, in equilibrium, must be equal to the aggregate supply, Y (equation 3). Secondly, the National Accounts of Greece do not distinguish between military expenditure satisfied by domestic production and military expenditure to finance imported defence materiel.

In this economy aggregate output is

$$Y = M + C \quad (3)$$

where Y is real GDP or spending, and total input usage is

$$L = L_m + L_c \quad (4)$$

and

$$K = K_m + K_c \quad (5)$$

where L and K are the total labour and capital stocks in the economy.

The model also allows the possibility that factor productivities vary across sectors. However, since productivity differences between the two sectors are in fact an empirical rather than a theoretical question, it is generally assumed that the ratio of respective marginal factor productivities in the two sectors deviates from unity by a factor, i.e.,

$$M_L/C_L = M_K / C_K = 1 + \delta \quad (6)$$

where the subscripts denote partial derivatives of the production functions with respect to the subscripted input, and δ is an unknown constant. If δ is positive, factors of production have larger marginal productivities in the defence sector, and vice versa if δ is negative. If δ is zero, marginal productivities are equal across the two sectors.

Taking the total differential of Y in equation (3) and using equations (1) and (2) gives

$$dY = dM + dC = M_L dL_m + M_K dK_m + C_L dL_c + C_K dK_C + C_M dM$$

where CM denotes the marginal externality effect of military spending on the output of the civilian sector. Eliminating M_L and M_K using equation (6) and collecting yields

$$dY = C_L (dL_m + dL_C) + C_K (dK_m + dK_C) + \delta (C_L dL_m + C_K dK_m) + C_M dM$$

From equations (4) and (5), $dL = dL_m + dL_c$ and $dK = dK_m + dK_c$. Also, since CL=ML/(1+) and CK=MK/(1+Δ), the term in the last parenthesis is equal to [l/(1+δ)]dM.

Making the substitutions gives

$$dY = C_L\ dL + C_K\ dK + [\delta(1+\delta)]\ dM + C_M\ dM \quad (7)$$

Dividing each side of equation (7) by Y, it can be written in terms of growth rates as

$$dY/Y = a_1\ (dL/L) + a_2\ (I/Y) + a_3\ (dM/M)\ (M/Y) \quad (8)$$

where α_1 = CL (L/Y), α2 = CK and α_3 = δ/(1+δ) + CM are parameters to be estimated and I = dK, i.e. aggregate real investment spending in the economy (a full development of the supply side model analysed above is presented in the Appendix).

Equation (8) predicts a positive relationship among economic growth, the employment growth and investment share, providing that the marginal products of labour and capital are positive in the civilian sector. In this model, the effect of military expenditure on economic growth is viewed as the result of the combination of externality and productivity effects. In Feder's (1982) own words, the coefficient of the military expenditure term should be interpreted as a measure of the difference between the marginal contribution to GDP of production factors in the two sectors, relative to the marginal contributions of these factors to the defence sector's output. In other words, the rate of growth of GDP is composed of the contribution of factor accumulation (i.e., growth of labour and capital) and the gains or losses brought about by shifting factors from the civilian to the defence sector. Evidently, the predicted sign of the military expenditure term depends on the signs of δ and CM. Although a priori expectations state that marginal factor productivities may be lower in the defence sector[9], there is no theoretical basis for such an assumption. Also, there is no a priori assumption about the sign of the marginal external product of military expenditure in the civilian sector, because military spending is being treated as an externality and may have a positive, negative or zero effect. Therefore, the sign of the military expenditure term is the main empirical question.

Some observations appear appropriate in regard to the structure and basic assumptions of the above model. First, the analysis focuses on the potential non-optimality of resource allocation between the defence and civilian sectors, which reflects the need to consider the economy as consisting of two distinct sectors. However, splitting the economy into a number of distinct sectors is not, , possible, in reality, but it does provide a useful abstraction. Some sectors such as the military may, stand outside the rest of the economy, while others are much more involved. In setting out an approach that adopts a number of distinct sectors, it is fully acknowledged that it is just, a model, but it is hoped to capture the important real interactions.

Secondly, the implicit assumption that the productivity differential δ is the same for labour and capital is a simplification. It would be possible to develop a simultaneous equations model, based on the two sectoral production functions, taking into account separate productivity differentials and cross externality effects, but it could not readily be estimated due to data limitations. Separate data would be needed for the capital stock and labour employed in the defence sector and for that used in the civilian sector.

Thirdly, the production-function framework developed above leads to a single equation growth model assuming that military expenditure is exogenous to economic growth. In other words, the model implicitly assumes that military expenditure precedes economic performance. By contrast, Joerding (1986) and Chowdhury (1991) note that it is equally plausible to expect that economic growth may cause military spending. In the case of Greece, however, security has been the major national concern for most of the post-war period. The disputes between Greece and Turkey over the Aegean Sea's continental shelf, the width of Greek territorial waters and Greece's airspace limits, as well as the Turkish invasion of Cyprus in 1974 have led Greek governments to maintain high levels of military expenditure regardless of the country's economic performance[10]. In fact, some researchers have offered empirical verification to the argument that Greek military expenditure has been primarily determined by the Greek-Turkish conflict over the post-war period (Majeski and Jones, 1981; Majeski, 1985; Kapopoulos and Lazaretou, 1993; Kollias, 1994b, 1996; Refenes, Kollias and Zapranis, 1995). In other words, the driving force of Greek military spending has been historically dictated by the need to respond to the Eastern threat, which means that military expenditure is exogenous to Greece's economic growth. In order to test this exogeneity empirically, we employed the Granger (1969) causality test, which reveals that military expenditure causes economic growth, and not the other way around (see Table 1)[11]. Therefore, the estimation of the above specified growth equation will not introduce severe bias attributable to the existence of interdependence between military expenditure and growth in the Greek economy.

TABLE 1

Tests of Granger Causality

	F-values	
	dY/Y	M
Null hypothesis:		
	**	
dY/Y is not Granger caused by M	5.336	
	(2,31)	
Null hypothesis:		
M is not Granger caused by dY/Y		1.850
		(2,31)

Notes
(i) Degrees of freedom are presented in parentheses below the F-values.
(ii)(**) denotes significance at the 5% level.

4. Empirical Results

The main focus of this study is on obtaining the direction and strength of the overall effect of military expenditure on the growth process of the Greek economy. Simplifying the notation and adding a constant term in equation (8), the growth-defence relationship takes the form

$$y_t = \alpha_0 + \alpha_1 l_t + \alpha_2 i_t + \alpha_3 m_t + u_t$$

where y stands for the output growth rate, l for the growth rate of labour, i for the investment share and m for the defence sector variable. This equation is used throughout the empirical work of this paper.

Annual data in constant 1970 prices on all variables were extracted from the National Accounts of Greece. In the absence of data on the labour force, the growth rate of this variable was proxied by the growth rate of population (p). The problems encountered in the attempt to deflate military expenditure are well known and useful discussions are provided by SIPRI (1983) and Smith (1989). Most studies deflate military expenditure either by the consumers' price index (CPI) or by the GDP deflator (Murdoch and Sandler, 1990). In this study the military price deflator was approximated by the price index of government final consumption expenditure, because in the National Accounts of Greece total military expenditure is considered as a part of government consumption.

As Engle and Granger (1987) point out, if the concept of equilibrium is to have any meaning or relevance, the processes underlying the relationship between the output growth rate and its determinants should be such that the "disequilibrium errors" u_t should tend to fluctuate around their mean value, or show some systematic tendency to become small over time. A minimal condition for equilibrium is that the variables in the equilibrium relationship should be cointegrated. A prerequisite for testing a set of variables for cointegration is to establish the properties of the individual series. The relevant Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for unit roots and stationarity indicate that the hypothesis of a unit root in ρ and i cannot be rejected while the hypothesis of a unit root in y, m, Δ ρ and Δi is rejected at least at the 5% level[12]. Therefore, some of the variables in question are integrated of order one (I(1)) and the classical least squares techniques are inapplicable in this case study.

The most popular methods for estimating equations with integrated variables are the Engle and Granger (E-G) two-step procedure (Engle and Granger, 1987) and Johansen's vector autoregression approach (Johansen and Juselius, 1989). We opted for the E-G approach for two reasons. First, although Johansen's procedure offers a unified framework for estimation and testing, it is primarily concerned with the statistical properties of cointegrated series and secondarily with their economic properties. Secondly, VAR estimates, in general, cannot be interpreted as structural coefficients. Most empirical studies employing Johansen's procedure have examined the relationship between income and consumption, where an explicit theoretical structure is not assumed, rather particular hypotheses are examined (e.g., Brodin and Nymoen, 1992; Patterson, 1994).

In practice, the E-G procedure consists of estimating by OLS the presumed equilibrium relationship (i.e. the cointegrating regression) and then testing the residuals for stationarity. If the residuals are I(O), i.e. stationary, the null hypothesis of noncointegration is rejected and the OLS estimators are "super-consistent" (Stock, 1987)[13]. Then, the cointegrating regression is indeed a long-term equilibrium relationship and we can then move to the second step, namely the OLS estimation of a dynamic short-run equation, in which the residuals of the cointegrating regression serve as an error correction mechanism which accounts for short-run disequilibrium. According to the "Granger Representation Theorem" (Granger, 1983; Engle and Granger, 1987), such a dynamic short-run equation exists if the variables in question are cointegrated and its estimators are not only consistent, but are as efficient asymptotically as those that would be obtained if the true value of the cointegrating vector were known and used in the second stage.

The major problem with the cointegrating regression is that it is not perfectly clear which variables we are allowed to include. In principle, one should not include variables which are not I(1), but in practice one may include any stationary variable as long as it does not affect the remaining coefficients and the critical values of the test statistics (Engle and Granger, 1991).

4.1 The Long-Run Relationship

The OLS estimates from fitting equation (8) to annual data of the Greek economy for the period 1958-93 are reported in Table 2. Strictly speaking, it is not possible to draw any statistical inferences from these results since, as some of the series are non-stationary, useful tests such as the F and t-statistics do not follow the standard distributions. Even the parameter estimates may not be unbi-

TABLE 2

The Long-Run Economic Growth-Military Expenditure Relationship in Greece

Explanatory Variables	Dependent Variable: y_t	
	Equation (8)	Conven. Neoclass. Model
	* * *	* * *
Constant	-8.962 (-3.985)	-8.070 (-3.582)
P_t	0.094 (0.085)	-0.127 (-0.113)
	* * *	* * *
i_t	0.573 (6.518)	0.529 (6.109)
	* *	
m_t	-1.693 (-1.723)	
Summary Statistics		
R^2	0.531	0.503
SEE	2.399	2.469
CRDW	2.437	2.363
F	14.252	18.771
Diagnostics		
AR (2)	2.533	2.087
ARCH (1)	2.698	1.487
RESET	0.415	0.439
NORM (2)	1.768	1.741

Notes

(i) y=the growth rate of real GDP, p=the growth rate of population, i=real investment as a share of real GDP, m=real military expenditure as a share of real GDP. Data are in constant 1970 prices.

(Ii) R^2=the coefficient of multiple determination adjusted for degrees of freedom, SEE=the standard error of the regression, CRDW=the Cointegrating Regression Durbin-Watson statistic, F=the regression F-statistic.

(iii) The diagnostics have the following meaning: AR (q) is the qth order X^2 test for residual autocorrelation, ARCH (q-1) is the qth order X^2 test for autoregressive conditional heteroskedasticity, RESET is the F test for functional misspecification and NORM (2) is the skewness and excess kurtosis X^2 test under the null hypothesis of normality. For details see Cuthbertson, Hall and Taylor (1992).

(iv) t — values in parentheses; (*) denotes significance at the 10% level, (**) at the 5% level and (***) at the 1% level.

ased, though they are consistent. However, the relative advantage of the EG procedure is that we choose in advance one variable for the left-hand side of the equation, thus assuming that a given structural relationship among the variables involved exists. Consequently, though not strictly legitimate from the econometric point of view, we can interpret the coefficient estimates of the cointegrating regression as representing structural parameters (Engle and Granger, 1987).

The estimated equation is reasonably well defined in terms of the standard criteria as they are reported therein. The Lagrange multiplier (AR), ARCH (Engle, 1982), RESET (Ramsey, 1974) and NORM (Bera and Jarque, 1982) statistics do not provide evidence for rejecting the null hypotheses of no autocorrelation, homoskedasticity, no functional misspecification bias and normality. The estimated parameters are easily interpreted. The coefficient related to investment share, capturing the marginal product of capital in the civilian sector, is positive and significant at the 1% level with a magnitude of about 0.6. The coefficient associated with population growth is not significantly different from zero, though it possesses the expected sign, while the coefficient of the defence sector variable is significant at the 5% level and has a negative sign. The results, therefore, lend support to the hypothesis that military expenditure retards economic growth in Greece through the combined relative factor productivity differential and externality effect of the defence sector[14].

To test the null hypothesis of noncointegration of the variables included in equation (8) two tests are used: the Cointegrating Regression Durbin-Watson (CRDW) statistic (Engle and Granger, 1987) and the ADF statistic (Davidson and Mackinnon, 1993). The CRDW statistic is 2.437 indicating that the variables in question are cointegrated[15]. However, since Engle and Granger themselves suggest that the CRDW test might be used only for a quick approximate result, and DeJong et al. (1992) have shown that the ADF test outperforms most alternatives, we moved to the second test which is based on the residuals from fitting equation (8). The regression equation run was of the form

$$\Delta\hat{u}_t = f\hat{u}_{t-1} + \sum_{i=1}^{m} n_i \Delta\hat{u}_{t-i}$$

where $\hat{u}_t$ stands for the estimated residuals of the cointegrating regression (8),with m=4[16]. Since the coefficient of $\hat{u}_{t-1}$ was significant at the 1% level, the null hypothesis of noncointegration should be rejected[17]. Therefore, the ADF statistic, along with the CRDW statistic, provide enough indications in favour of cointegration, so that we may assert that equation (8) does describe a long-run equilibrium relationship.

In addition to a discussion of the statistical results summarized in Table 2, some observations seem appropriate in regard to the specificational choice of equation (8). First, the relatively low value of R^2 in this regression should be attributed to a number of omitted explanatory variables, such as human capital endowments, economic structure, political orientation and historical and cultural factors (Landau, 1986). Also, as Feder (1982), Ram (1986) and Alexander (1990) have demonstrated, the size of the export and government sectors may be important determinants of the output growth rate. The omitted variables problem was tested to some extent using an extended version of equation (8) to incorporate both real exports and general government consumption expenditure[18]. The use of government consumption as opposed to total government expenditure was in an attempt to capture discretionary changes in government spending (Alexander, 1990). The estimated coefficients of the additional explanatory variables were found to be positive but generally insignificant (the coefficient of the government expenditure variable was marginally significant at the 10% level). An F-test to discriminate between the two models gave an F-value of 1.174 which is not significant at the 5%, indicating that the additional regressors do not improve the explanatory power of equation (8). The results therefore suggest that military spending is different from other forms of government and private expenditure, at least as far as their growth effects are concerned.

Secondly, the results of equation (8) can be contrasted to those of a widely-used specification of the growth equation, usually referred to as the "conventional" neoclassical model. This specification assumes absence of externalities, i.e. $CM = 0$, and for a given set of prices, a situation where $\delta = 0$, reflecting an allocation of resources which maximizes national output. Under these assumptions, GDP growth is the result of capital and labour growth only. The regression result of this formulation for the Greek economy is reported in Table 2. Comparison of the two models highlights the superior explanatory power of equation (8). The value of the R^2 is increased and that of the standard error of the regression is reduced when the specification allowing for differences in marginal productivities and the presence of an externality effect of the defence sector is used.

Thirdly, from equation (8) one can get an estimate of the direction and strength of the overall effect of military expenditure on economic growth, without producing separate estimates of the defence externality effect (CM) and the factor productivity differential (δ). Some authors (Alexander, 1990; Atesoglu and Mueller, 1990) attempted to decompose the combined externality and productivity effect of defence, assuming that military expenditure affects the production of the civilian sector with constant elasticity. This approach yields a model similar to equation (8) in which the proportional rate of change of military spending (dM/M) serves as an additional regressor[19]. However, any attempt in the literature to estimate this model has not given in general significant estimates of the different effects due to strong multicollinearity. Our own estimates for Greece produced similar results[20].

4.2 The Short-Run Relationship

In the next step of the E-G cointegration methodology, the lagged values of the residuals of the long-run equation serve as an error correction mechanism in a short-run dynamic equation, where the explanatory variables are in first differences or lagged first differences. This equation only includes stationary variables, thus from the econometric point of view it is a standard single equation where all the classical diagnostic and misspecification tests are applicable.

Table 3 reports the OLS estimates of the short-run equation with various combinations of the explanatory variables (equations 1-3). The regressions appear to be satisfactory on the usual criteria as they are reported therein. The diagnostics do not detect any deviation from classical properties, and the RESET test does not indicate the existence of functional misspecification bias indicating that the equation is sufficiently enriched in dynamics. The explanatory power of the regressions is considerably higher compared to that of the long-term equation and the error correction term has the expected negative coefficient and is significant at the 1% level in all cases. The evidence suggests that changes in Greek output growth rates are positively related with contemporaneous changes in population growth and investment share, negatively related with contemporaneous changes in military expenditure and positively related with the previous period's changes in military spending. However, the net effect of defence on the economic growth of Greece appears to be negative. Overall, the results of the short-term dynamics are consistent with those of the cointegrating regression, and indicate that military expenditure retards the output growth rates in Greece.

TABLE 3

The Short-Run Economic Growth-Military Expenditure Relationship in Greece

Explanatory Variables	Dependent Variable: Δy_t					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.039 (-0.117)	-0.060 (-0.179)	-0.007 (-0.020)	0.321 (0.545)	0.269 (0.456)	0.119 (0.186)
Δp_t	** 2.577 (2.250)	** 2.471 (2.159)	** 2.772 (2.349)	** 2.634 (2.275)	** 2.527 (2.179)	** 2.769 (2.298)
Δi_t	*** 0.839 (5.571)	*** 0.810 (5.315)	*** 0.884 (5.581)	*** 0.799 (4.953)	*** 0.774 (4.759)	*** 0.866 (4.849)
Δm_t	*** -2.271 (-3.212)	*** -2.285 (-3.244)	* -1.546 (-1.698)	*** -2.372 (-3.269)	*** -2.376 (-3.281)	* -1.623 (-1.647)
Δy_{t-1}		-0.152 (-1.103)			-0.145 (-1.045)	
Δp_{t-1}			-0.554 (-0.409)			-0.545 (-0.394)
Δi_{t-1}			0.110 (0.665)			0.091 (0.491)
Δm_{t-1}			* 1.377 (1.590)			* 1.299 (1.373)

(continues)

	***	***	***	***	***	***
$\hat{u}_{t-1}$	-1.168	-0.927	-1.097	-1.180	-0.947	-1.100
	(-7.058)	(-3.388)	(-5.751)	(-7.038)	(-3.406)	(-5.637)
w				-0.573	-0.523	-0.206
				(-0.753)	(-0.686)	(-0.236)
Summary Statistics						
$\bar{R}^2$	0.745	0.747	0.741	0.740	0.741	0.730
SEE	1.880	1.872	1.895	1.896	1.892	1.935
DW	1.407	1.572	1.396	1.396	1.555	1.399
F	22.943	18.751	13.275	18.162	15.374	11.146
Diagnostics						
AR (2)	1.507	1.573	2.383	2.247	2.218	3.259
ARCH (1)	3.545	2.654	2.358	3.248	3.169	2.540
RESET	0.843	0.893	0.167	1.233	0.943	0.161
NORM (2)	0.457	0.094	1.281	0.470	0.030	1.000

Notes
(i) u_t = the estimated residuals of the cointegrating regression (8), w = dummy variable for the threat of war.
(ii) Remaining details as in Table 2.

An explicit mention in regard to the structure of the short-run growth equation appears necessary in this respect. The Turkish invasion of Cyprus in 1974 as well as the other disputes between Greece and Turkey, have created a strategic environment that might have adverse effects on the growth process of the Greek economy in the post-1974 period[21]. On the one hand, the threat of war causes uncertainties and dangers that do not augur well for investment and growth. On the other hand, it is easier to mobilize and harness resources for investment in threat of war-time than in peace-time (Gyimah-Brempong, 1989). To investigate the effects of the threat of war on the output growth rates of the Greek economy, the short-run equation was re-estimated with a dummy variable which took the value of 0 for the period 1958-73 and the value of 1 for the period 1974-93. The results (equations 4-6 in Table 3) indicate that no structural shift has occurred in the growth equation in the post-1974 period.

Before concluding, it is useful to bear in mind the advantages and limitations of the E-G two-step procedure. Combination of the two steps provides a complete model incorporating both the long-run static and the short-run dynamic models. It is claimed that this approach has the advantage that estimation of the two steps is quite separate so that changes in the dynamic model do not enforce re-estimation of the static model obtained in the first step. In other words, the long-run estimates of the postulated relationship have good properties without the need to make any prior assumptions about the dynamics in the data-generating mechanisms. As such, the E-G approach offers a tractable modeling procedure. On the other hand it has been criticized on the grounds that the estimates of the cointegrating regression have rather poor finite sample characteristics, particularly in the case where the explanatory power of the model is substantially low. The point to be made is that, just like any other estimation results, our estimates can at best be indicative and suggestive, but not conclusive, and should therefore be treated as such.

5. Conclusions

The purpose of this paper has been to contribute to current research on the subject of the growth-defence relationship by investigating the growth effects of military expenditure in Greece over the period 1958-93.

Most researchers consider that the effects of military expenditure on economic growth are transmitted through four main channels, namely the creation of aggregate demand, the possible reduction of investment, the broad spectrum of spin-offs that the military might provide for economic growth and the crowding-out effects of the work force. To capture those influences, this paper has specified a growth-defence relationship based on the two-sector neoclassical production-function framework, which allows the level of activity in one sector to act as an externality in another sector, and also permits marginal factor productivities to vary between the two sectors. This equation was tested on the grounds of the cointegration technique and the related notion of error correction to evaluate the long-run determinants of the output growth rates in Greece and to examine the short-term dynamics. Overall, the results suggest that military expenditure retards the output growth rates in Greece, contrary to the inconclusive findings of previous studies. In addition, the growth-defence relationship in this country has remained structurally stable over the entire time period considered.

An important implication of the empirical results of this paper is that a reduction in Greek military burdens will enhance the process of economic development in this country. However, the end of the Cold War and the East-West arms race has not yet led to appreciable reductions in Greek military spending, mainly because of the ongoing Greek-Turkish conflict. Thus, the prospects of a peace dividend for this country cannot be considered to be promising. Given the complexity of the issues involved, a reduction in the tension between the two countries could be achieved through a gradual, step-by-step approach to their bilateral differences, rather than a major break-through and improvement of their relations. An arms control agreement aimed to lead to a balance of power at lower armaments levels, would allow the reallocation of resources devoted to defence to other, more productive uses in the economy, yielding a peace dividend for both countries.

APPENDIX

This appendix presents the full development of the supply sided model analysed above.

We assume that there are two sectors in the economy which are mutually exclusive and exhaustive with respect to output. We call these sectors M for defence and C for the civilian sector of the economy. Labour L and capital K are the main inputs to each sector, although the defence sector can be thought of as affecting the output of the civilian sector, positively or negatively. Given the analysis of Section 3 on externality effects, the production functions underlying the structure of the economy can be written as

$$M = M(L_m, K_m) \tag{1}$$

$$C = C(L_c, K_c, M) \tag{2}$$

where M and C are real valued functions. Differentiating each of these equations we get

$$dM = ML\ dLm + M_K\ dKm \tag{3}$$

$$dC = C_L\ dL_c + C_K\ dK_c + C_M\ dM \tag{4}$$

where the lowercase subscripts denote the sectoral inputs of labour and capital and the uppercase subscripts denote partial derivatives of the production functions with respect to the subscripted input.

Moreover, taking marginal productivities in the C sector as a base, we assume that the marginal products of labour and capital in the defence sector may be higher or lower by a factor of $1 + \delta$. Thus, we assume that

$$M_L/C_L = M_K / C_K = 1 + \delta \tag{5}$$

Since by definition

$$Y = M + C$$

it follows that

$$dY = dM + dC \tag{6}$$

Substituting equations (3) and (4) into equation (6) and using equation (5) to eliminate ML and Mϰ, we have

$$dY=M_L\ dLm + M_K\ dKm + C_L\ dL_c + C_K\ dK_c + C_M\ dM =$$

$$=(1+\delta)\ C_L dLm + (1+\delta)\ C_K\ dKm + C_L\ dL_c + C_K\ dK_c + C_M\ dM$$

expanding to

$$dY=C_L\,(dLm + dLc)+C_K\,(dKm+dK_c) + \delta\,(C_L\,dLm + C_K\,dKm)+C_M dM$$

This simplifies even further if we note that

$L = L_m + L_C$

$K = K_m + K_C$

and

$dL = dLm + dL_C$

$dK = dKm + dK_C = I$

where I is aggregate real investment spending in the economy. Thus

$$dY = C_L\ dL + C_K I + \delta\ (C_L\ dLm + C_K\ dKm) + C_M\ dM \qquad (7)$$

Using equation (5) we can transform the term in the parenthesis of the last equation into the following

$$C_L\ dLm + C_K\ dKm = \frac{M_L}{1+\delta}\ dLm + \frac{M_K}{1+\delta}\ dKm =$$

$$= \frac{1}{1+\delta}\ (M_L\ dLm + M_K\ dKm) = \frac{1}{1+\delta}\ dM \qquad (8)$$

Substituting equation (8) into equation (7) we have

$$dY = C_L\ dL + C_K I + \frac{\delta}{1+\delta}\ dM + C_M dM = C_L\ dL + C_K I + (\frac{\delta}{1+\delta} + C_M)dM$$

On dividing through by Y this becomes

$$dY/Y = C_L(L/Y)\ (dL/L) + C_K\ (I/Y) + [\delta/(1+\delta) + C_M]\ (dM/M)\ (M/Y) =$$

$$= \alpha_1\ (dL/L) + \alpha_2\ (I/Y) + \alpha_3\ (dM/M)\ (M/Y)$$

where $\alpha_1 = C_L\ (L/Y)$, $\alpha_2 = C_K$ and $\alpha_3 = \delta\ /(1+\delta) + C_M$.

Notes

1. For details on the causes of diversity in the results, see Smith (1978), Brjoska (1981) and Chan (1987). Biswas and Ram (1986) and Alexander (1990) provide excellent reviews of the specificational choices adopted by the various studies.

2. Representative case specific studies include Deger and Sen (1983) and Faini, Annez and Taylor (1984) for India, Looney (1986) for Venezuela and Argentina, Chan (1988) and Davis and Chan (1990) for Taiwan, Atesoglu and Mueller (1990), Huang and Mintz (1990, 1991) and Mueller and Atesoglu (1993) for the USA, Scheetz (1991) for Argentina, Chile, Paraguay and Peru, and Hong (1990), Moon and Hyun (1992), Park (1993) and Heo (1996) for South Korea.

3. Source: SIPRI Yearbooks, "World Armaments and Disarmament", various issues.

4. For a comprehensive discussion on Greek fiscal problems and economic performance, see Alogoskoufis (1995).

5. Source: EUROPEAN ECONOMY, Annual Economic Report for 1995, no. 59,1995.

6. Excellent surveys of the macroeconomic effects of military expenditure are given in Kinsella (1990) and Fontanel (1994).

7. A two-way causality between military expenditure and unemployment has been postulated by the "underconsumption thesis" (often referred to as "military Keynesianism"), according to which military spending increases demand for monopoly defence products, absorbs surplus capital and stimulates profit making. Consequently, the capitalist state is able to ward off economic crisis and collapse through manipulation of the defence budget (see Baran and Sweezy, 1966; Mandel, 1968; Magaziner and Reich, 1982; Reich, 1983).

8. A number of important points have been raised concerning the usefulness of military expenditure as a defence measure (see for example Anderton (1989)). However, the discussion of such points is well beyond the scope of this paper.

9. The defence sector may be a relatively less competitive part of the economy as far as it operates without strong competitive pressure to induce adaptability, innovativeness and efficiency in the management and use of resources (Atesoglu and Mueller, 1990).

10. An overview of the main issues of friction between the two countries can be found in Wilson (1979), Clogg (1991), Larrabee (1992), Georgiou, Kapopoulos and Lazaretou (1996) and Kollias (1996).

11. The Granger causality test is formulated on the basis of a VAR specification in the variables of interest, namely

$$(dY/Y)_t = a_o + \sum_{i=1}^{m} a_i \, (dY/Y)_{t-i} + \sum_{j=1}^{n} b_j \, M_{t-j} + e_{1t}$$

$$M_t = c_o + \sum_{i=1}^{k} c_i \, M_{t-i} + \sum_{j=1}^{p} d_j \, (dY/Y)_{t-j} + e_{2t}$$

where the number of lags m, n, k and p is chosen so as to induce a white noise disturbance term. The hypothesis of causality is then tested by a standard F-test for the joint significance of b_j (j=1, ..., n) and d_j (j=1, ..., p). See Harvey (1983).

12. To test the hypothesis of a unit root in a variable X the following OLS regression is run:

$$\Delta X_t = c_o + c_1 t + c_2 X_{t-1} + \sum_{i=1}^{m} \beta_i \, \Delta X_{t-i} + \varepsilon_t$$

where m, the number of lags in the dependent variable, is chosen so as to induce a white noise disturbance term. The test statistic suggested is the standard t — ratio for the estimate of c_2 (critical values provided by Fuller, 1976, Table 8.5.2), or the F-statistic of null restrictions for the joint significance of c_1 and c_2 (critical values provided by Dickey and Fuller, 1981, Table VI). The results of the relevant tests are available on request from the author.

13. Super consistent are the estimates which converge on the true but unknown population parameters with an order of convergence of l/n instead of the customary rate of l/ n, where η is the number of observations. This implies that the OLS estimators converge on the true values at a faster rate in the non-stationary than in the stationary case (Holden and Thompson, 1992). However, consistency is asymptotic, and in small samples, bias may be substantial. Stock (1984) shows the finite-sample bias to be of order l/n.

14. If instead of constant marginal factor productivities we assume constancy of the factor shares, the production-function framework adopted in this paper yields a single equation that allows for direct estimates of elasticities rather than marginal products. To develop a constant factor share, single equation model, equation (8) can be used to derive the elasticities of Y with respect to M and L. These are given by

$$e_M = (dY/Y) \ / \ (dM/M) = [\delta/(1+\delta) + C_M] \ (M/Y) = \alpha_3 \ (M/Y)$$

$$\text{and } e_L = (dY/Y) \ / \ (dL/L) = C_L \ (L/Y) = \alpha_1$$

where the parameters α_1 and α_3 are the corresponding coefficients of equation (8). The regression equation then becomes

$$dY/Y = e_L \ (dL/L) + a_2 \ (I/Y) + e_M \ (dM/M)$$

Assuming that the economy is competitive it can easily be shown that the elasticities are also the factor shares (Solow, 1957). Adding an intercept and estimating the above equation by OLS gives a value of -0.098 (t= -1.887) for e_M which means that a 1% increase in military expenditure leads to a reduction of the output growth rate of the Greek economy by 0.09%.

15. The null hypothesis is DW = 0. Critical values for three variable cases are 0.488, 0.367 and 0.308 at 1%, 5% and 10% level, respectively (Hall, 1986, p. 233).

16. The major problem with the ADF statistic is that it might be sensitive with respect to the number of augmentations, i.e. the choice of the lag length for the specification of the Dickey-Fuller regression. Said and Dickey (1984) suggest to set the truncation lag in relation to the sample size. Thus, if m denotes the lag order and η the sample size, m needs to grow in proportion with n, at a controlled rate η . This rule, however, is nonrobust with respect to the assumptions that $m.n^{1/3}$ —>O, and that there exists n, r>o such that $c.m>n^{1/r}$. In practice it is impossible to check for these conditions. Ng and Perron (1994) argue that it is preferable to use data dependent rules which take into account sample information. They favour the use of information based rules such as information criteria and conventional t and F significance tests. After examining their relative performance they conclude that the conventional significance tests have more robust properties across models. It was therefore decided to follow Ng and Perron (1994) and specify the Dickey-Fuller regression according to the t — statistics of the additional augmentations. Thus, given our limited sample size, we assumed a four period lag length for the specification of this regression.

17. The null hypothesis is $l\hat{U}_t \sim I(1)$. Critical values for three variable cases are -3.89, -3.13 and -2.82 at 1%, 5% and 10% level, respectively (Hall, 1986, p. 233).

18. The regression equation was of the form

$$dY/Y=\beta_o + \beta_1(dL/L) + \beta_2(I/Y) + \beta_3(dM/M)(M/Y) + \beta_4(dX/X)(X/Y)+\beta_5(dG/G)(G/Y)$$

where X denotes real exports and G real government consumption expenditure. The formal derivation of the specification of this equation is given in Alexander (1990). Data were from the National Accounts of Greece. The results are available on request from the author.

19. Assuming that military expenditure affects the civilian output with constant elasticity φ, the production function of the civilian sector takes the form $C = M\varphi\Psi(L_c, Kc)$. In this case it can be shown that $C_M = \varphi(C/M)$ and equation (8) reduces to

$$dY/Y = \gamma_1 (dL/L) + \gamma_2 (I/Y) + \gamma_3 (dM/M)(M/Y) + \gamma_4 (dM/M)$$

where $\gamma_1 = C_L (L/Y)$, $\gamma_2=C_K$, $\gamma_3 = \delta/(1+) - \varphi$ and $\gamma_4=\varphi$. This form gives $\delta=(\gamma_3+\gamma_4)/1-(\gamma_3+\gamma_4)$ which combined with the estimate of α_3 in equation (8) gives $CM=\alpha_3-(\gamma_3+\gamma_4)$.

20. The results are available on request from the author.

21. The Cyprus invasion surely constitutes the strongest exogenous shock to the system. Greece temporarily withdrew from NATO's military wing and changed its strategy towards committing its forces to a confrontation with Turkey.

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