Chapter XX

Assessing the Effects of Military Expenditure on Growth

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Abstract

Military spending is an expenditure by governments that has influence beyond the resources it takes up, especially when it leads to or facilitates conflicts. This chapter provides an overview of the issues involved in analysing the effects of military spending on growth. It considers the alternative general economic theories that inform the development of models to undertake empirical analyses, and estimation issues in undertaking those analyses. The Feder-Ram model, the modified Solow and the endogenous growth models, are discussed in detail, before being estimated to illustrate the issues involved in estimating the models and to compare their performance.

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1. Introduction

Assessing the importance of military spending to the economy remains an important task, especially given the growth in military spending in recent years and the recent financial crisis and recession. According to SIPRI (2008) world military spending in 2007 was $1339 billion, 2.5% of world GDP, an increase from 2006 of 6% in real terms. Indeed, between 1998 and 2007 military spending increased by 45% in real terms, a trend due at least in part to the second Gulf War and the massive intervention of the US in Afghanistan after the 9/11 terrorist attack. As shown in Figure 1, there was a change in the trend in regional shares of military spending in GDP at the end of the nineties, the most marked change being the growth in United States military burden, with the declines of the nineties bottoming out and subsequently increasing for East Asia and South America. Over this period World military expenditure was between 2.5 and 3 percent of world GDP.

INSERT FIGURE 1 HERE

Although the political justification of much of the growth of military spending is usually based on the need to maintain national security, these recent dynamics have led to renewed debate over whether the increase of the military expenditure enhances or deteriorates economic growth and welfare. While this has been a central issue of the economic debate during the 1980s and 1990s it was one that did not achieve a clear empirical consensus among scholars, reflecting to a large degree the heterogeneity in the approaches used and differences in the sample of countries covered and the time periods covered (Dunne at al. 2005). Early cross-country correlation analyses by Benoit (1973; 1978) quickly gave way to a variety of econometric models, reflecting different theoretical perspectives. Keynesian, neoclassical and structuralist models provided a variety of specifications for different samples of countries. The diversity of results led to arguments for case studies of individual countries and relatively homogeneous groups of countries (Dunne, 1996).

This chapter provides an overview of the issues involved in analysing the effects of military spending on growth. Section two considers the alternative general economic theories that inform the development of models to undertake empirical analyses, followed by a discussion of the estimation issues in section 3. Section 4 then considers the alternative formal models that are common in the literature, the Feder Ram model, the modified Solow and the endogenous growth models and Section 5 presents some empirical results, to illustrate the issue involved in estimating the models and to compare their performance. Finally, Section 6 provides some concluding remarks.

2. General Theories of the Economic of Military Spending

To interpret the results of any empirical study it is necessary to have a theory, even though this may not of itself be verifiable. For research on the economic effects of military spending this is complicated by the fact that much of economic theory does not have an explicit role for military spending as a distinctive economic activity. However, this has not prevented the development of theoretical analyses, with three basic positions being adopted in the literature on both developed and developing countries. The neoclassical approach sees the state as a rational actor which balances the opportunity costs and security benefits of military spending in order to maximise a well defined national interest reflected in a societal social welfare function. Military expenditure can then be treated as a pure public good and the economic effects of military expenditure are determined by its opportunity cost, with a clear trade off between civil and military spending. This approach readily allows consistent formal theoretical models to be developed to inform empirical work and has had a major influence on the literature. It can, however, be criticised for being ahistoric, always able to justify observed actions, concentrating on the supply side, ignoring the internal role of the military and military interests, implying a national consensus and requiring extreme knowledge and unrealistic computational abilities of the rational actors (Smith, 1977).

The most influential neoclassical model was the Feder-Ram model (Biswas and Ram , 1986) but this has recently come under intense criticism by Dunne et al (2005). This neoclassical strand of the literature has been the most influential and the models are discussed in more detail in Section 4. Other developments saw new classical economists using military expenditure as an important shock to the system, which can have dynamic real effects on output and more recently attempts to introduce military spending into endogenous growth models.

An alternative Keynesian approach saw a proactive state using military spending as one aspect of state spending to increase output, through multiplier effects in the presence of ineffective aggregate demand. Military spending can then lead to increased capacity utilisation, increased profits and hence increased investment and growth (eg Faini et al. (1984)). It has been criticised for its failure to consider supply side issues, leading many researchers to include explicit production functions in their Keynesian models (eg Deger and Smith, 1983). More radical Keynesian perspectives have focused on the way in which high military spending can lead to industrial inefficiencies and to the development of a powerful interest group composed of individuals, firms and organisations who benefit from defence spending, usually referred to as the military industrial complex (MIC). The MIC increases military expenditure through internal pressure within the state even when there is no threat to justify such expenditures (Dunne and Sköns, 2010).

The Marxist approach sees the role of military spending in capitalist development as important though contradictory. There are a number of strands to the approach which differ in their treatment of crisis, the extent to which they see military expenditure as necessary to capitalist development, and the role of the MIC in class struggle. One offshoot of this approach has provided the only theory in which military spending is both important in itself and an integral component of the theoretical analysis, the underconsumptionist approach. Developed from Baran and Sweezy (1966) this sees military expenditure as important in overcoming realisation crises, allowing the absorption of surplus without increasing wages and so maintaining profits. No other form of government spending can fulfil this role. While this approach has been extremely influential in the general economic development literature, empirical work within this approach has tended to be limited to developed economies (Smith, 1977; Coulomb, 2004).

Moving beyond a broad stroke theoretical understanding towards an empirical analysis it becomes necessary to be more specific about the questions to be addressed and the way in which they are to be analysed. There are choices to be made many of which will be conditioned on the theoretical perspective adopted and the data availability. The level of level of abstraction at which the empirical analysis should operate needs to be determined; the theory needs to be operationalised, identifying the concrete concepts to be used in the empirical analysis guided by the theory; the type of empirical analysis has to be decided, qualitative, quantitative, historical, institutional or some combination of these; the time period has to be chosen, restricted by available data and the sample of countries has to be chosen; the empirical method has to be chosen. If individual country case studies are undertaken they provide the opportunity for more detailed study, but are providing different information to cross country studies. It is also possible that military spending may have a different effect at different times, providing a boost to industrialisation but in the end providing a drag on further development. Results of empirical studies will be sensitive to the measurement and definition of the variables, to the specification of the estimated equations (especially the other variables included), the type of data used and the estimation method (Dunne, 1996).

3. Estimation Issues

In the applied work on the economic effects of military spending a number of econometric approaches have been used. Firstly, single equation analyses which use economic growth as the dependent variable and military spending (burden, per capita or absolute value) as the, or one of the, independent variables, based on or informed by a structural model reflecting the approaches discussed in the previous section. Other studies took an alternative path and investigated the causal links (using statistical definitions of causality referred to as "Granger causality" to distinguish the concept from theoretical causality) between military expenditure and economic growth without developing a structural model. Using dynamic regression or Vector Autoregressive (VAR) models has the advantage that they are dynamic specifications, free of economic assumptions imposed a priori. Researchers, such as Kinsella (1990), Kinsella and Chung (1998) and Dunne and Vougas (1999), Dunne et al (2001), began to develop the analysis to allow for long run information in the data and more recent literature has used Johansen's cointegrating VAR framework. This led to a number of cross country and case studies, recent examples of which are Abu Bader and Abu Qarn (2003), Kollias et al (2004) and Tang et al (2009). Some have a structural model in mind when the start determining the VAR, others do not. A recent critical and comprehensive review of these studies, Dunne and Smith (2010), suggests that having a structural model is important in determining the direction of causality. Other empirical studies focus on threshold analyses (eg Reitschuler and Loening, 2005) and non linearities

Berthelemy et al (1994) used models of endogenous growth based on Romer's work to analyse the impact of military spending on growth for India and Pakistan This led to further endogenous growth models used to simulate (Sheih et al, 2007) and estimate the impact of military spending on growth and to consider non linearities a recent example being Pieroni (2009). These models have also been developed to account for the allocation of public spending and complementarities (d'Agostino et al, 2010).

A second approach adopted simultaneous equation systems, which emphasise the importance of the interdependence between military spending, growth and the other variables, including Smith and Smith (1980), Deger and Smith (1983), Deger (1986), Gyimah-Brempong (1989) Mohammed (1992) and Scheetz (1991). The studies did vary in their use of data. Some deal with cross section averages (eg Deger and Smith, 1983), others with time series estimates for individual countries (eg Scheetz, 1991; Dunne and Nikolaidou, 2001), while others are more comprehensive (eg Dunne and Mohammed, 1995). Use of these models has diminished though a recent example is Atemoglou (2009).

A third approach used macroeconometric and other forms of world models. A pioneering study by Leontief and Duchin (1980) used a macroeconometric model of the world economy to analyse the global effects of disarmament in the major powers and a transference of the resources to low income countries. Cappelen et al (1982) made similar analysis findings, while Gigenhack et al (1987) use the Systems Analysis Research Unit Model (SARUM) and an arms dynamics equation, of the action reaction type, to simulate the effects of different security scenarios. Other world models introduced forward looking expectations mechanisms eg McKibbin (1995). There are a number of studies using macrodels in Gleditsch et al (1996), but few individual country studies for developing and middle income countries using relatively large macromodels for obvious reasons. Exceptions are Adams et al (1992) and Marwah et al, (2002), using Keynesian macroeconometric models and Athanassiou et al (2002) and Ozdemir and Bayar (2009) using CGE models. A further literature has developed on the opportunity cost of military spending, or the trade off between military spending and other forms of welfare expenditure (eg Ozoy, 2002). While this approach is somewhat problematic, as it suggests that if money was not spent on military spending it would be spent elsewhere and it often does not allow for the fact that it is possible to have more of both with economic growth (Dunne and Uye, 2009)

A major problem in estimating growth models has been the lack of independent exogenous variation in the data. One way of overcoming this has been by pooling cross section and time series data for a relatively homogenous group of countries (Murdoch et al, 1997). There is a problem that the cross section and time series parameter may be measuring different things. The former could be picking up the long run effects and the latter the short run and the pooled relation is then a weighted average of the two. Growth equations have been most successful in cross sections, because of the difficulties of distinguishing the cyclical demand side effects from medium term supply side growth effects. More recently the growing length of the data series and the availability of reliable cross country data and developments in panel data estimation methods have led to a marked increase in the analysis of economic growth in panels (Smith and Fuertes, 2010) and its relation to military spending (Dunne et al, 2005).

The available methods provide a variety of approaches to attempt to deal with some of these issues. The pooled OLS approach:

(1) $$y_{it} = a + b x_{it} + u_{it}$$

assumes all parameters are the same for each country and invariant across time, while the fixed effects estimator:

(2) $$y_{it} = a_i + b \mathrm{x}_{\mathrm{it}} + \mathrm{u}_{\mathrm{it}}$$

allows the intercept to differ across countries which ignores all information in the cross sectional relation. Time fixed effects can also be allowed for separately or together with country fixed effects in a two-way fixed effect model:

(3) $$y_{jt} = a_t + a_i + b \mathrm{x}_{\mathrm{it}} + \mathrm{u}_{\mathrm{it}}$$

In dynamic models of the form

(4) $$y_{it} = a_i + b x_{it} + l_{it-1} + \mathrm{u}_{\mathrm{it}}$$

the fixed effect estimator is not efficient, because of lagged dependent variable bias, which biases the OLS estimator of λ downwards. It is, however, consistent in the limit when the number of time periods goes to infinity, and for samples of the size used here the bias is small. Thus a dynamic fixed effects specification can provide a useful starting point (Dunne et al, 2002). Other dynamic approaches developed for large N studies difference to remove the fixed effects and then estimate using instrumental variables for the lagged dependent variable –often using GMM rather than regression methods (a recent example is Yildirim et al, 2005). If the parameters differ over groups there is a further heterogeneity bias, which can be dealt with by estimating each equation individually and taking an average of the individual estimates (Smith and Fuertes, 2010).

4. Modelling the Economic Effects of Military Spending

For empirical analyses on the effects of military spending on growth operationalise the theory to form an applied model. This leads to a variety of empirical work from applied econometric to more focussed institutional case study analyses. When statistical analysis is undertaken, it is generally based on the Keynesian or neoclassical approaches, as these are most amenable to the creation of formal models (Dunne, 1996). One interesting feature of the debate has been the popularity of what was called the Feder-Ram model, despite a number of deficiencies identified in Dunne et al (2005). The major alternatives have been a modified Solow growth model and increasingly endogenous growth models. This section reviews these models.

The Feder-Ram Model

This supply-side model was originally developed to analyse the impact of the export sector on economic growth in developing economies. Using it for military spending allows the military sector to be treated as one sector in the economy and the externality effect of the sector and its differential productivity effect to be distinguished within a single-equation model. These apparent advantages have led to it having a profile within the defence economics area well beyond what it has achieved in other areas.

The basic two-sector version of the model distinguishes between military output (M) and civilian output (C), with both sectors employing homogeneous labour (L) and capital (K), and military production affecting civilian production activity while θ represent the elasticity of C with respect to M:

(5) $$M = M(L_m, K_m), \quad C = C(L_c, K_c) = M^{\theta} c(L_c, K_c)\ .$$

with constraints:

(6) $$L = \sum\nolimits_{i \in S} L_i, \quad K = \sum\nolimits_{i \in S} K_i, \quad S = \{m, c\}$$

and domestic income:

(7) $$Y = C + M\ .$$

As Dunne et al (2005) point out the summation of "butter" and "guns" in (7) is only admissible if C and M are understood to represent monetary output values rather than output quantities. Making the implicit price normalisation in (7) transparent by re-writing it in the equivalent form

(8) $$Y = P_c Cr(L_c, K_c) + P_m Mr(L_m, K_m),$$

where P_m and P_c denote the (constant unitary) money prices associated with the real output quantities Mr and Cr. The model allows the values of the marginal products of both labour $(M_L,\ C_L)$ and capital $(M_K,\ C_K)$ to differ across sectors by a constant uniform proportion, i.e.

(9) $$\frac{M_L}{C_L} = \frac{M_K}{C_K} = \frac{P_m Mr_L}{P_c Cr_L} = \frac{P_m Mr_K}{P_c Cr_K} = 1 + \mu.$$

Dependent on the price relation used in the evaluation of sectoral outputs. Differentiating (7) with (5) and (6) yields the growth equation

(10) $$\hat{Y} = \frac{C_L L}{Y}\hat{L} + C_K \frac{I}{Y} + \left(\frac{\mu}{1+\mu} + C_M\right)\frac{M}{Y}\hat{M}\ ,$$

where hat notation is used to indicate proportional rates of change and I = dK denotes net investment. Using the fact that the far RHS of (1) entails a constant elasticity of C with respect to M, (9) can be restated in the form

(11) $$\hat{Y} = \frac{C_L L}{Y}\hat{L} + C_K \frac{I}{Y} + \left(\frac{\mu}{1+\mu} - \theta\right)\frac{M}{Y}\hat{M} + \theta \hat{M}$$

which permits - at least in principle - the separate identification of the externality effect and the "marginal factor productivity differential effect". As Dunne et al (2005) show the notion of a marginal factor productivity differential between sectors in the model is a source of interpretational pitfalls. A non-zero μ is interpreted one sector is "less efficient" or "less productive" in its factor use than the other due to the presence of some sort of organisational slack or X inefficiency and that such interpretations are not consistent with the underlying theoretical model.

In addition to these theoretical issues, there are a number of econometric problems in estimating the Feder Ram model. In early studies the model was estimated using cross sectional data. In this case the main problem was multicollinearity between the final two terms in the estimating equation and a concern with using possibly insignificant coefficients to compute the externality effect. Expanded versions of the model added to this problem. When the model was estimated using time series data the multicollinearity problem remained and others were added. Firstly, there was often a lack of independent exogenous variation in the data, though this has been overcome to some degree by the use of the panel data methods discussed below. Secondly the model is specified in growth rates which limit the dynamics to a single lags. Attempts to provide a more general specification increased the problems of multicollinearity and identification of the composite coefficients. All of these problems go some way to explain the variation in the results encountered in the empirical analyses and when combined with problems of interpretation led to a sense of dissatisfaction in a number of studies (Dunne et al, (2005) provide a survey.

__Neoclassical Growth Model__

Dunne et al (2005) argue that problems with the Feder-Ram model are serious enough to limit its value in empirical work and suggest an alternative model based on a modified Solow growth model with Harrod-neutral technical progress as operationalised for cross-country analysis by Mankiw, Romer and Weil (1992). The starting point for the model is the aggregate neoclassical production function featuring labour-augmenting technological progress

(12) $$Y(t) = K(t)^{\alpha}[A(t)L(t)]^{1-\alpha}$$

where Y denotes aggregate real income, K is the real capital stock, L is labour, and the technology parameter A evolves according to

(13) $$A(t) = A_o e^{gt} m(t)^{\theta},$$

where g is the exogenous rate of Harrod-neutral technical progress and m is an index of military expenditure such as the share of defence spending in GDP. Taking the standard Solow model assumptions (constant saving rate s; constant labour force growth rate n; constant rate of capital depreciation d), gives the dynamics of capital accumulation:

(14) $$\dot{k}_e = sk_e^{\alpha} - (g+n+d)k_e \iff \frac{\partial \ln k_e}{\partial t} = se^{(\alpha-1)\ln k_e} - (g+n+d),$$

where $\mathrm{k_e} := \mathrm{K}/\left[\mathrm{AL}\right]$ denotes the effective capital-labour ratio and α is the constant capital-output elasticity. The steady-state level of k_e is

(15) $$k_e^{*} = \left[\frac{s}{g+n+d}\right]^{1/(1-\alpha)}.$$

and linearizing (14) via a truncated Taylor series expansion around the steady state[1] and using (15), gives

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[1] Re-writing (3) in the form $\mathrm{du/dt{=}f(u),u{:=}ln(ke)}$, the linearized form is $\mathrm{f(u^*){+}f'(u^*)\left[u(t){-}u^*\right]}$

(16) $$\frac{\partial \ln k_e}{\partial t} = (\alpha - 1)(g + n + d)[\ln k_e(t) - \ln k_e^*] .$$

The steady-state level of output per effective labour unit is

(17) $$y_e^* = \left[\frac{s}{g + n + d} \right]^{\alpha/(1-\alpha)}$$

with

(18) $$\frac{\partial \ln y_e}{\partial t} = (\alpha - 1)(g + n + d)[\ln y_e(t) - \ln y_e^*] .$$

In order to operationalize (18) for empirical work, we integrate the equation forward from t-1 to t and get

(19) $$\ln y_e(t) = e^z \ln y_e(t-1) + (1 - e^z) \ln y_e^*, \quad z \equiv (\alpha - 1)(n + g + d) .$$

Using (13), (17) and (19), y_e is related to observable per capita income y:= Y/L via

(20) $$\begin{aligned} \ln y(t) &= e^z \ln y(t-1) + (1 - e^z)\left\{ \ln A_o + \frac{\alpha}{1-\alpha}[\ln s - \ln(n + g + d)] \right\} \\ &+ \theta \ln m(t) - e^z \theta \ln m(t-1) + (t - (t-1)e^z) g \end{aligned} .$$

Equation (20) suggests the dynamic panel data model

(21) $$\ln y_{i,t} = \beta_0 \ln y_{i,t-1} + \sum_{j=1}^{4} \beta_j \ln x_{j,i,t} + \eta_t + \mu_i + \nu$$

where x_1= s = gross investment/GDP, x_2 = n+g+d = labour force growth rate + 0.05, x_3 = m = military expenditure/GDP and x_4 = m_{t-1} [2]. Following Knight et al (1993; 1996) and Islam (1995) s and n are treated as varying across countries and time, while g and d are taken to be uniform time-invariant constants and A_o is country-specific but, by construction, time-invariant.

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[2] With

$\gamma = e^z > 0; \beta_1 = (1 - e^z)\alpha/(1-\alpha) > 0; \beta_2 = -\beta_1 < 0; \beta_3 = \theta; \beta_4 = -e^z\theta = -\gamma\beta_3; \ \eta_t = g(t - (t-1)e^z); \ \mu_i = (1 - e^z)A_o$

Dunne et al (2005) show how this model can be augmented to deal with human capital, following Mankiw, Romer and Weil (1992) and re-specifying the aggregate production function as[3]

(22) $$Y(t) = K(t)^{\alpha} H(t)^{\beta} [A(t)L(t)]^{1-\alpha-\beta},$$

Giving the equation for income per actual worker which provides the basis for the empirical analysis as

(23) $$\ln y(t) = e^{z} \ln y(t-1) + (1-e^{z}) \left\{ \ln A_{o} + \frac{\alpha}{1-\alpha-\beta} \ln s_{k} + \frac{\beta}{1-\alpha-\beta} \ln s_{h} - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+d)] \right\}$$
$$+ \theta \ln m(t) - e^{z} \theta \ln m(t-1) + (t-(t-1)e^{z})g$$

and suggesting the dynamic panel model specification

(24) $$\ln y_{i,t} = \beta_0 \ln y_{i,t-1} + \sum_{j=1}^{5} \beta_j \ln x_{j,i,t} + \eta_t + \mu_i + \nu$$

where $x_1 = s =$ gross investment / GDP, $x_2 = n + g + d =$ labour force growth rate $+ 0.05$, $x_3 = m =$ military expenditure / GDP, $x_4 = m_{t-1}$; $x_5 =$ human capital investment / GDP[4].

This model represents an improvement over the Feder-Ram and has been used in a number of recent studies (eg Yakovlev, 2007). It provides a consistent specification, with testable hypotheses for coefficients and when estimated is easy to interpret.

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[3] Temple(2001) provides some critical reflection on the plausibility of this specification.

[4] $\beta_0 = e^z > 0$; $\beta_1 = (1-e^z)\alpha/(1-\alpha-\beta) > 0$; $\beta_2 = -(\beta_1 + \beta_5) < 0$; $\beta_3 = \theta$; $\beta_4 = -e^z\theta = -\beta_0\beta_3$; $\beta_5 = (1-e^z)\beta/(1-\alpha-\beta) > 0$; $\eta_t = g(t-(t-1)e^z)$; $\mu_i = (1-e^z)A_o$.

While theses exogenous growth models provide a valuable explanation of convergence in growth between countries, they came under criticism for failing to explain the observed growth in living standards. Endogenous growth models were developed to allow for divergences in growth rates and income and to allow for constant or increasing return to capital.

Endogenous Growth Model

Within the literature the alternative approach that has been gaining popularity in the literature uses the endogenous growth models originally developed by Barro (1990). In principle this provides a more general framework for the analysis, but at the cost of increasing complexity and difficulties of interpretation.

The basic model starts by assuming that a representative agent produces a single commodity using a generic production function by the amount of private capital, k, and total public spending, g

$$y = Af\left(\frac{g}{k}\right) \tag{25}$$

where A is the exogenous rate of technology and f is a generic function formalized as a constant elasticity function (CES), Cobb-Douglas or a logarithmic function. The growth of private capital is modelled as:

$$\dot{k} = (1-\tau)y - c \tag{26}$$

in which $\dot{k}$ is growth rate of private capital, τ is the flat rate of income tax and c is private consumption. The agent chooses the amount of private consumption to maximize the flow of future utility functions:

$$U(c) = e^{-\rho t}u(c) \tag{27}$$

where ρ is the rate of time preferences. If the utility function is specified as a CES function,

(28) $$u(c)=\frac{c^{1-\sigma}-1}{1-\sigma}.$$

Since $\sigma>0$, the marginal elasticity is $-\sigma$. Government expenditure G is determined by the amount of collected taxes of the private sector

(29) $$G=\tau y$$

The agent then maximizes the utility function (28) subject to a private capital accumulation constraint (26) and a government budget constraint (29) to choose the optimal growth rate, giving:

(30) $$\gamma=\frac{1}{\sigma}\left((1-\tau)f'\left(\frac{g}{k}\right)-\rho\right)$$

Which can be written as:

(31) $$\gamma=\frac{1}{\sigma}\left((1-\tau)f\left(\frac{g}{k}\right)(1-\eta)-\rho\right)$$

where η is the elasticity of γ with respect to g (for given values of k), so that $0<\eta<1$. Government spending can have two effects on the growth rate. First, an increase in τ can reduce γ and second an increase of g/y can raises $\partial y/\partial k$, which raises γ. Typically, the first of these dominates when government spending is large and the second when the government spending in GDP is small.

To illustrate consider the production function of Cobb-Douglas rather than CES form. The elasticity of y with respect to g is constant and $\eta=\alpha$, such as the conditions $\tau=g/y$ and $g/k=(g/y)\phi(g/k)$ imply that the derivative of γ with respect to g/y is:

(32) $$\frac{d\gamma}{d(g/y)} = \frac{1}{\sigma}\phi\left(\frac{g}{k}\right)(\phi'-1)$$

Hence, the growth rate increases with g/y if g/k is small enough such that $\phi'>1$ and declines with g/y if g/k is large enough such that $\phi'<1$. In the Cobb-Douglas technology, the optimal size of government that maximises the growth rate corresponds to the condition for productive efficiency, that is $\phi'=1$. Since $\alpha=\eta=\phi'(g/y)$, it follows that $\alpha=g/y=\tau$. This implies that their will exist an inverse hump-shaped relationship between government spending and the growth rate and so an optimal level of government spending.

Military spending can be introduced by extending (3.1) to give:

(33) $$y = Ak^{1-\alpha-\beta}g_1^{\alpha}g_2^{\beta} \qquad 0<\alpha,\beta<1$$

where k is the private capital stock, g_1, military government spending, and g_2 non-military government spending. The growth of private capital is then:

(34) $$\dot{k} = (1-\tau)Ak^{1-\alpha-\beta}g_1^{\alpha}g_2^{\beta} - c$$

The representative household now chooses the optimal amount of private consumption subject to the government spending constraint:

(35) $$G = g_1 + g_2 = \tau y$$

Taking φ and $1-\varphi$ as respectively the fraction of resources allocated to military and non-military spending, the flows of government spending are allocated by using the following rules:

(36) $$g_1 = \varphi\tau y$$

(37) $$g_2 = (1-\varphi)\tau y$$

By solving the model, the corresponding steady-state growth rate can be written as:

$$(38) \qquad \frac{\dot{c}}{c} = \gamma = \left[(1-\alpha-\beta)(1-\tau)\phi^{\alpha}(1-\phi)^{\beta} A\left(\frac{G}{k}\right)^{(\alpha+\beta)} - \rho \right]$$

By rearranging (38) in terms of ϕ, such as $G/k = \left(\tau A\phi^{\alpha}(1-\phi)^{\beta}\right)^{1-\alpha-\beta}$, and, differentiating it with respect to ϕ, we obtain:

$$(39) \qquad \frac{\partial\gamma}{\partial\phi} = \frac{1}{\theta}\left[j\phi^{\frac{\alpha}{1-\alpha-\beta}}(1-\phi)^{\frac{\beta}{1-\alpha-\beta}}\left[\alpha\phi^{-1} - \beta(1-\phi)^{-1}\right]\right]$$

in which $j = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}(\tau)^{\frac{\alpha+\beta}{1-\alpha-\beta}}$.

To predict the sign of the impact of the military burden on growth rate, (39) is differentiated with respect to the share of military government expenditure, ϕ. It follows that:

$$(40) \qquad \begin{array}{l} \left\{ \frac{\alpha}{\phi} < \frac{\beta}{1-\phi} \Rightarrow \frac{d\gamma}{d\phi} < 0 \right\} \\ \left\{ \frac{\alpha}{\phi} > \frac{\beta}{1-\phi} \Rightarrow \frac{d\gamma}{d\phi} > 0 \right\} \end{array}$$

This means that the impact of military spending on growth depends the productivity parameters related to its initial share of total spending. If ϕ is higher than its optimal level, the military burden has a negative impact on the growth rate.

Barro (1990) introduces government expenditure as a public good into the production function which means the rate of return to private capital increases, which can stimulates private investment and growth. A simplified estimable version of the model, distinguishes military expenditure from general expenditure and assumes that it may indirectly affect economic growth by providing security from external threat and helping to protect property rights, which increases the probability that an investor will receive the marginal product of capital (Barro and Sala-i-Martin, 1992).

This basic model has spurred a number of developments. Devarajan et al. (1996) developed an intertemporal-optimizing endogenous growth model to examine the components of government's resource allocation and, as a specific case, considers the defence and non-defence sectors. A straightforward extension of the model was carried out by d'Agostino et al. (2009a) in which non-military government spending was shared by public investments and current government consumption with the respective potential productivity. Although Stroup and Heckelman (2001) does not explicitly formalize an endogenous growth model, they extend the Barro-type specification to include military spending and to evaluate a non-linear form of the relationship, which is supported by their data. The task of identifying nonlinearities in the military spending-growth nexus, was then taken up in Aizemann and Glick (2006), which uses an endogenous growth model in which the effects of military spending are augmented by an interaction variable that measures the external threat. However, the model fails to take into account for the competitive allocation with each other public good. In fact, as shown by Pieroni (2009), the partial effect of military expenditure on growth can vary according to the different initial shares of government expenditure on non-military categories even when a proxy of threat is included in the estimations. The results obtained nonparametrically by the same sample of Aizemann and Glick (2006) indicate that the marginal effect of a change military burden is not constant both across different levels of the variable and across economies and can lead, in the extreme case, to the existence of multiple growth regimes.

Recently the literature addressed to extend the endogenous growth model by recognizing a prominent role for the quality of governance of a country arisen from growth literature (see, for example Mauro (1995) and Gupta et al. 2000). Its role is to directly affect the economic performance of a country and, indirectly, the allocation of military spending. d'Agostino et al. (2010) consider the complementarities between military spending and corruption, with corruption to shifting resources to the military sector, subtracting more efficient public sectors (civilian investments). The relevance of the extended endogenous model is the possibility to include other ingredients of the cited relationship and to evaluate interaction effects of the impact of military spending on economic growth.

5. Applications

To illustrate the application of the Feder-Ram and modified Solow models and the issues involved in a panel data context we use data are for 28 countries over the period 1960-1997 for GDP, GDP per-capita, and gross domestic fixed capital formation as a measure of investment. These are measured in constant price US dollar values at 1990 exchange rates and price levels (Source: World Bank). In addition, there are data on military expenditure as a share of GDP from SIPRI. The sample consists of two groups: 17 OECD countries (Germany, France, Italy, Netherland, Belgium, UK, Denmark, Spain, Greece, Portugal, USA, Canada, Japan, Australia, Norway, Sweden, Turkey) and 9 other countries (Argentina, Brazil, Chile, Venezuela, South Africa, Malaysia, Phillipines, India, Israel, Pakistan, and South Korea).

To operationalise the Feder-Ram model for empirical application the instantaneous rates of change of the variables in are replaced by their discrete equivalents giving

$$(41)\quad \begin{aligned}\Delta Yt / Yt-1 \;=\; & \alpha_0 \;+\; \alpha_1 \;\Delta L_t / L_{t-1} \;+\; \alpha_2 \; I_t / Y_{t-1} \;+\; \alpha_3 \Delta M_t / M_{t-1} \left(M_t / Y_{t-1}\right) \\ & + \alpha_4 \;\Delta M_t / M_{t-1}\end{aligned} \;.$$

Estimating this equation for the 28 countries give the results reported in Table 1 for the one and two-way fixed effects and the Swamy random coefficient estimator.

INSERT TABLE 1 HERE

The one-way fixed effects model provides poor results for a growth equation with the labour and capital variables insignificant and the trend term significant but negative. The military spending terms are also insignificant. Moving to a two-way fixed effects model improves the significance of the variables and gives both size and externality effects as positive. The random coefficient estimates differ with only the capital term significant and significantly larger in magnitude. Neither of the military expenditure terms is significant.

These results are rather poor as might be expected and illustrate the problems and limitations of using and interpreting consistently results from the Feder Ram model. Despite these problems and limitations applications of the Feder Ram model provided numerous contributions to the guns-and-butter debate[5]. Examples include Antonakis (1997), Sezgin (1996), Batchelor, Dunne and Saal (1999), Mintz and Stevenson (1995), Antonakis (1999) and Atesoglu and Mueller(1990). Variants have been estimated using cross-country data (e.g Biswas and Ram (1986)), time series data for individual countries (e.g. Huang and Mintz (1991), Ward et al. (1993), Sezgin (1997)), and pooled cross-section time-series data (e.g. Alexander (1990), Murdoch et al. (1997)). In the past such results have led to suggestions of expanding the model to introduce more sectors, including Alexander (1990), Huang and Mintz (1991), Murdoch et al

[5] See Ram (1995) for a survey up to the early 1990s and Dunne and Uye (2009) for a later one.

(1997), or attempting to improve the dynamics, as in Birdi and Dunne (2001) and Yilirim and Sezgin, 2002. However, given the criticisms in Dunne et al (2005) outlined above, the best response is to consider an alternative model.

The modified Solow growth model developed in the previous section suggests the dynamic panel data specification

(42) $$\ln y_{i,t} = \gamma \ln y_{i,t-1} + \sum_{j=1}^{4} \beta_j \ln x_{j,i,t} + \eta_t + \mu_i + \nu_{i,t}$$

where $x_1 = s = I/Y$; $x_2 = n+g+d = \Delta L/L$; $x_3 = m = M/Y$; $x_4 = m_{t-1}$

From the development of the theory we have a number of expectations for the signs and magnitudes of the coefficients: $\gamma = e^z$ should be in the range $0<\gamma<1$ and should be close to unity for the empirically relevant range of $z = (\alpha-1)(n+g+d)<0$; $\beta_1 = (1-e^z)\alpha/ (1- \alpha) > 0$, and the value for α jointly identified by γ and $\beta 1$ should be within the typical range for the capital share in GDP of around 0.3 to 0.5; $\beta_2 = - \beta_1 < 0$; $\beta_3 = \theta$ measures the elasticity of long-run per-capita income with respect to the military expenditure share, and $\beta_4 = - e^z \theta = - \gamma\beta_3$.

Estimating the model gives the results in Table 2 below, for one and two-way fixed effects and the random coefficient models.

INSERT TABLE 2 HERE

These results provide estimates that are entirely consistent with the expectations developed from the theory. The coefficient on lagged log output γ is positive and close to unity as we would expect, and the coefficient on the investment share, β_1, has likewise the expected sign. The value for the capital-output elasticity α implied by the estimated coefficients for γ and β_1 is 0.5 for the fixed effects models and thus broadly in line with observable capital share figures, while the implied α of 0.73 for the ECM regression is rather high. The coefficient on the labour force growth term, β_2, is both negative and close in absolute value to β_1 and significant for the fixed effects models. The coefficient on the log of the military share β_3 is negative and significant for the fixed effects models, suggesting that a permanent one percent increase in m reduces long-run per-capita income permanently by 0.03 to 0.04 percent.(or: ... suggesting that a permanent increase in m lowers the steady-state growth path of per-capita income permanently by 0.03 to 0.04 percent). As expected, β_4 has the opposite sign to β_3 and is of similar magnitude with significant estimates for the fixed effects models. The trend parameter ηt represents the impact of the rate of technical progress, which is assumed to be the same across all countries. This is significant and positive for the RCM model and while positive for the one way fixed effects model is not significant.

Clearly both the size and the significance of the coefficients vary between the fixed and the random coefficient models. The existence of heterogeneity will bias γ towards one, and so we might expect a decrease in the coefficient with the RCM, but in fact the estimate is the same for all models. Certainly the results are rather encouraging, giving a sensible specification and seem a big improvement on the Feder Ram. Other recent studies illustare the value of the model including Yakovlev(2007) and Heo(2009).

To illustrate the application of the Barro model a cross country panel of 53 African countries for the period 2003-2007 developed for d'Agostino et al (2010) is used[6]. To provide an empirically tractable model from equation (28), the panel specification with fixed effects assumes that technological parameter A accounts for the initial level of GDP (in logs). The other variables are the annual growth rate of per-capita GDP at constant prices (γ) and military spending (mil) and consumption and investment expressed as percentages of GDP.

INSERT TABLE 3 HERE

The first column in Table 3 reports the fixed effects estimations after that we shared non-military spending by public investments and current government spending[7]. The results are consistent with theoretical expectations, showing a negative impact of the military sector on growth. As a policy implication, a high share of military spending in GDP appears, therefore, responsible for lower performances of economic growth. The second column shows the results of a two-step GMM estimation of the growth equation 28 using a dynamic panel data approach (see Arellano and Bond (1991); Arellano and Bover (1995), Blundell and Bond (1998). Adjusted standard errors of the second step by using the finite-sample correction are used for inference (Windmeijer, 2005). While the lagged dependent variable is not significant, the results are similar to the fixed effects model. There is a significant impact of military spending on growth rate, with the estimate suggesting an elasticity of -0.6 for the effect of military burden on economic growth, consistent witht eh findings of recent studies Recent studies include Yakovlev (2007) and Mylonidis (2008).

[6] The main source of our data is the "African Development Indicators" (ADI), available from the World Bank (WBI).

[7] The current government spending is obtained as a residual component of total government spending.

There is another strand of literature focused on the case studies with time series of the impact of military spending on growth rate, in which nonlinearities are explicitly accounted for. For example, Gerace (2002) testing for counter-cyclical interaction between the growth rates of US military expenditures and GDP found no support for the hypothesis that these expenditures are negatively related to the GDP growth rate. Although the importance of external events in the US may influence the results, Cuaresma and Reitschuler (2004; 2006) test this relationship arguing that the main issue is the presence of non-linearities in the data. By using a threshold value for the military sector, they estimate the impact of military spending on per-capita growth rate above and below this value. In line with the prevalent theory, they find that for low levels of military spending there is a positive effect on growth rate and, vice-versa, whether the estimations are performed for higher level of military spending.

The use of endogenous growth models allows us to consider the impact of technology on growth and provides a more general framework. It gives flexibility in the treatment of some aspects of the processes at work, but at a cost. The models can quickly become complex and difficult to operationalise for econometric analysis and interpret. It is likely that modified Solow model will still have an important role to play in future work.

7. Conclusions

Military spending is an expenditure by governments that has influence beyond the resources it takes up, especially when it leads to or facilitates conflicts. While countries need some level of security to deal with internal and external threats, these have opportunity costs, as they prevent resources being used for other purposes that might improve the pace of development. Such issues are clearly important for the poorest economies. With the present growth in military spending internationally it is important to understand the economic implications. In addition, there are developments that aid the researchers. Longer data series are available, helping the application of the rapidly developing panel data series estimation methods, and there is more post cold war data available, increasing the signal noise ratio.

Within this increasingly data rich environment theoretical developments have also taken place. The Feder-Ram model which was the model of choice for a large number of past studies, has been shown to have a number of weaknesses and misinterpretations and the emphasis is shifting to other theoretical models. While there are important heterodox approaches, the main developments have been the use of exogenous and endogenous growth models. As this chapter has seen a simple modified Solow model, where military spending has an impact on growth through its effects on technology, performs well and is certainly preferable to the Feder Ram model. The use of endogenous growth models has some advantages in providing some flexibility in the treatment of aspects of growth, but at the cost of complexity.

The use of panel data methods for the relatively long time series available have been shown to be a potentially important new development for research in the area. Estimating the models using panel panel data, rather than simple cross-sections on averages, produced poor results for the Feder-Ram model, more promising results for the new growth model and illustrated the value of an endogenous growth approach. Both the exogenous growth model study of 28 countries and the endogenous growth model study of Africa suggest a negative effect of military spending on growth.

To put these results in context, Chan's (1985; 1987) surveys of the military spending growth literature, found a lack of consistency in the results, while Ram (1995) reviewed 29 studies, concluding little evidence of a positive effect of defence outlays on growth, but that it was also difficult to say the evidence supported a negative effect. Dunne (1996) covering 54 studies concluded that military spending had at best no effect on growth and was likely to have a negative effect, with certainly no evidence of positive effects and Smith (2000) argued the large literature did not indicate any robust empirical regularity, positive or negative, but suggested there probably is a small negative effect in the long run, but one that requires considerably more sophistication to find. Dunne and Uye (2009) summarise the results of 103 studies, finding for developing countries that almost 39% of the cross country studies and 35% of the case studies find a negative effect of military spending on growth, with only around 20% finding positive for both types of studies. They also add that as Hartley and Sandler (1995) pointed out, if we distinguish between the supply side models and those which have a demand side, there is more consistency in the results. Models allowing for a demand side and hence the possibility of crowding out investment tend to find negative effects, unless there is some reallocation to other forms of government spending, while those with only a supply side find positive, or positive but insignificant, effects. Thus the fact that the supply side models find a positive effect is not a surprise as the model is inherently structured to find such as result (Brauer, 2002).

This does seem strong evidence against there being a positive impact of military spending on the economy. This suggests that cuts in military spending are unlikely to have the negative economic effects that are often heralded in the media. A finding that is consistent with the experience of most major economies in the post Cold War period, that seem to have dealt with the downturn in military spending without economic problems.

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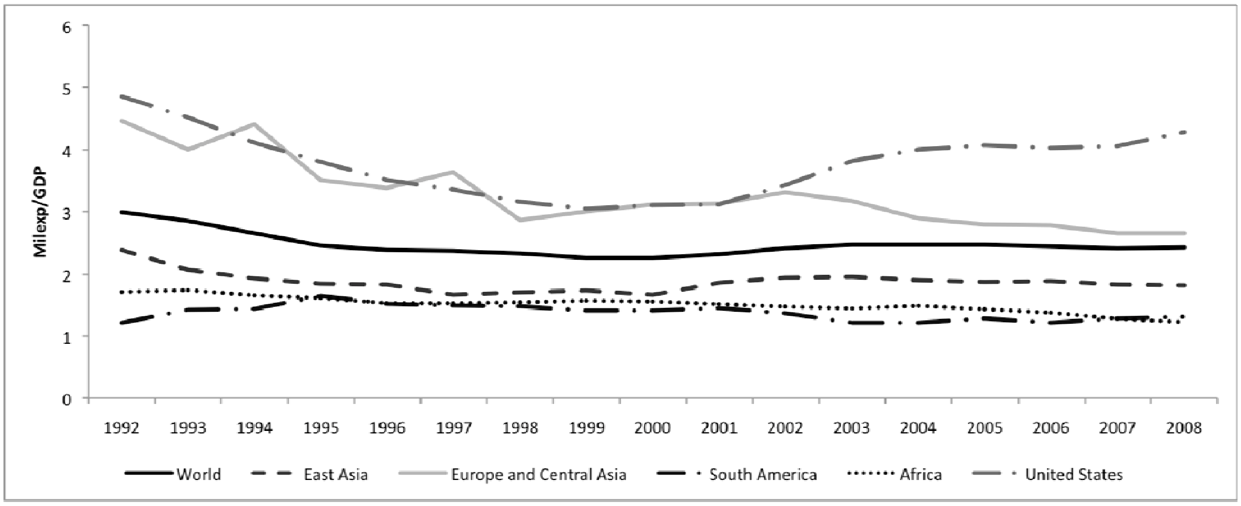
FIGURES

Figure 1 - World Regional Military Spending in GDP



Notes: The data are collected by the SIPRI yearbook, several years.

TABLES

Table 1: Feder-Ram Model

	Expect	Fixed effect One	Fixed effect Two	RCM
$\Delta L_t / L_{t-1}$	+	0.074	0.147	0.149
		(0.8)	(1.7)	(0.3)
I_t / Y_{t-1}	+	0.002	0.003	0.471
		(1.1)	(2.2)	(2.7)
$\Delta M_t / M_{t-1} \left(M_t / Y_{t-1}\right)$	-/+	-0.072	-0.008	11.15
		(-0.7)	(-1.5)	(-0.1)
$\Delta M_t / M_{t-1}$	-/+	0.016	0.025	-0.161
		(1.8)	(2.9)	(0.0)
t	-	-0.001		-0.0005
		(-8.2)		(-0.8)
θ Size effect		0.016	0.025	-0.161
μ Externality		-1.112	0.017	

Notes: The dependent variable is the GDP growth rate. We report in parenthesis the p-values.

Table 2: Modified Solow-Type Model

	Fixed effect One	Fixed effect Two	RCM
log Y_{t-1}	0.96	0.96	0.96
	(14.9)	(15.1)	(9.1)
$\log(I/Y)_t$	0.04	0.04	0.11
	(8.8)	(9.2)	(2.7)
$\log(n+g+d)_t$	-0.05	-0.04	-0.14
	(-4.9)	(-4.8)	(-1.2)
$\log(M/Y)_t$	-0.04	-0.03	-0.06
	(-5.3)	(-3.5)	(-1.0)
$\log(M/Y)_{t-1}$	0.03	0.02	0.06
	(3.7)	(2.9)	(1.2)
trend	0.27	-	0.01
	(1.5)		(1.4)

Notes: The dependent variable is the GDP growth rate. We report in parenthesis the p-values.

Table 3: Endogenous Growth Model

	Fixed Effect		Dynamic Panel	
log GDP_{t-1}	-15.124	**		
	(-5.926)			
γ_{t-1}			-0.058	
			(0.116)	
Milex	-0.982	**	-0.697	**
	(0.386)		(0.332)	
Pub investment	0.453	***	0.607	*
	(0.137)		(0.396)	
Gov consumption	-0.089		-0.299	*
	(0.127)		(0.163)	
Priv investment	0.372	**	0.037	***
	(0.145)		(0.014)	
Constant	6.332	*		
	(-4.289)			

Notes: The dependent variable is the GDP growth rate. We report in parenthesis the standard errors, while the asterisks stand for p-value. We have that * $p < 0.01$, ** $p < 0.05$, *** $p < 0.10$.