Theoretical and Econometric Issues in Analysing the Military Expenditure-Growth Nexus

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Abstract:

This paper surveys some of the theoretical and econometric issues involved in estimating growth models that include military spending. In particular, it critically evaluates the commonly used Feder-Ram model, detailing its problems and limitations and suggesting a more acceptable theoretical approach. It also surveys the econometric issues involved in estimating these models and uses a panel of 28 countries study to evaluate the different approaches and to draw some suggestions for the development of future research.

Preliminary draft. Comments welcome

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1. Introduction

There is now a large body of empirical literature investigating the economic effects of military spending, with no consensus as to what these effects might be. One reason for the variety of results is the variety of studies. The early cross-country correlation analyses of Benoit 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 variety of results led to arguments for case studies of individual countries and relatively homogeneous groups of countries (Dunne, 1996).

One interesting feature of the debate has been the popularity of particular types of models, in particular the Feder-Ram model. This supply side neoclassical growth model was 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 size effect of the sector and its differential productivity effect to be distinguished, all in a single equation model. These advantages have led to it having a profile within the defence economics area well beyond what it has achieved in other areas and has contributed to a failure of the area to embrace important new developments in the general growth and development literature.

This paper surveys some of the theoretical and econometric issues involved in estimating the commonly used Feder-Ram model, detailing its problems and limitations. It then moves on to suggest a more acceptable theoretical approach and compares the estimation results from the two approaches. Section 2 provides an overview of the theoretical approaches. Section 3 then provides an outline and detailed critique of the Feder-Ram model. An alternative Solow-type growth model is then developed in section 4. Section 5 considers the estimation methods for cross country analyses and section 6 then estimates a Feder-Ram model for a panel of 28 countries, with section 6 doing the same for the Solow-type growth model. Finally, section 7 presents some conclusions.

2. Modelling the Economic Effects of Military Spending

Theoretically, any evaluation of the impact of military spending on growth is contingent on the theoretical perspective used. Neoclassical models are generally supply side with a focus on the trade off between 'guns and butter. Keynesian models see military spending simply as one component of government spending and focus on the demand side, although when used in econometric models an aggregate production function does given them a neoclassical flavour. A group of institutional economists focus on the damaging impact of the military industrial complex on the economy and Marxists vary from the positive effects of the underconsumptionists, through preventing realisation crises to its possible negative impact on the profit rate, Dunne (1990)

When we move to empirical analyses it is necessary to determine the level of abstraction at which the analysis is to be presented and to operationalise the theory to form an applied model. This leads to a variety of empirical work from applied econometrics to more focussed institutional case study analyses. When statistical analysis is undertaken it is generally the neoclassical and Keynesian models that are used as these are most amenable to the creation of formal models, though some studies adopt a more ad hoc approach. The studies differ in terms of the country coverage, whether they use time series or cross section data, the time period covered and the empirical methods used (see Dunne, 1996).

In general the empirical analyses have identified a number of channels by which military spending can influence the economy and both can be positive or negative. It can take skilled labour away from civil production, but on the other hand can train workers, particularly in developing economies where the military may provide valuable skills. It can take the beat capital equipment from civil industry to produce a high technology enclave, on the other hand there may be positive externalities of the development of the military sector on the civil sector. It can lead to damaging wars, but may maintain peace and lead to economic benefits from more prosperous allies. It can stimulate demand in a stagnant economy and lead to growth, but may create bottlenecks in a constrained economy. Finally, it may slow down development through the fostering of a militaristic ideology, but on the other hand nationalist attitudes may increase effort and output and the military and ideology be used to control the workforce. Clearly whether these effects end up being positive or negative overall is an empirical question and the result is likely to differ across countries (see Dunne, 1996)

Following the ad hoc approach of Benoit's original study, which found a positive effect of military spending on growth in developing countries and impressive literature has been built up using econometric analysis of single equation reduced form equations and simultaneous equation models, which model both direct and indirect effects (Smith, 2000). In addition, macroeconometric have been used to simulate the likely impact of changes in military spending at country and international level (Gleditsch et al, 1996).

Overall the results of the empirical work has tended to show an insignificant or negative impact of military spending on economic growth in developing countries and a clearer negative impact in developed economies, through military spending being at the expense of investment rather than consumption. Such a summary does, however, hide the diversity of literature and results. Much of the earlier cross-section analyses found that the sample selection was important and this led to calls for more case studies. The time series analyses of individual economies and relatively homogenous groups of economies that resulted have improved understanding, but have also produced a variety of results. For this reason there is still considerable mileage in developing cross country studies, particularly when these develop the approach used, for example using new theoretical models or panel data methods. This paper does both.

3. Critical Review of Growth Models with Military Spending

When undertaking econometric studies of the military expenditure growth nexus, the simple Feder Ram has something of a fascination for defence economists, mainly because of its ability to explicitly treat externality effects of the military on the non-military sector.

Following the lead of Biswas and Ram[1986], who first adapted Feder [1983,1986]'s model of the exports-growth nexus in developing countries for a cross-country study of the link between military spending and economic growth, numerous empirical contributions to the guns-and-butter debate have employed variants of the same approach.[1] Deger and Sen[1995:284] characterise the Feder-Biswas-Ram externality model as "a splendid empirical workhorse to investigate the impact of military expenditure on growth". The approach is generally seen to provide a formal justification for the inclusion of military expenditure as an explanatory variable in a single-equation growth regression analysis, which is "grounded in the neoclassical theory of growth" (Mintz and Stevenson [1995:283]), or at least "fairly well grounded in the neoclassical production-function framework" (Biswas and Ram [1986:367]).[2] The charm and popularity of the approach lies certainly in the suggestion of a fast-track link from theoretical model to econometric specification with a fairly negligible amount of technical fuzz.

The basic two-sector version of the model distinguishes between military output (M) and civilian output (C).[3] Both sectors employ homogeneous labour (L) and capital (K), and the set-up allows for external effects of military production on civilian production activity:

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

The factor endowment constraints are given by

(2) $L = \sum_i L_i$, $K = \sum_i K_i$, $i \in \{m, c\}$,

[1] See Ram (1995) for a survey up to the early 1990s, and e.g. Antonakis[1997], Sezgin[1997] or Batchelor, Dunne and Saal[1999] for more recent examples of the genre.
[2] For similar pronouncements see e.g. Antonakis[1999:503] or Atesoglu and Mueller[1990:20] among many others.
[3] For multisectoral extensions of the model see e.g. Alexander[1990, 1995], Huang and Mintz[1991], Murdoch, Pi and Sandler[1997], Antonakis[1999], Nikolaidou[1999].

and real domestic income is

(3) Y = C + M.

As a matter of course, the summation of "butter" and "guns" in (3) is only admissible if C and M are understood to represent monetary output *values* rather than output *quantities*. It will be helpful for subsequent reference to re-write (3) in the equivalent form

(3') $Y = P_C\, Cr(L_c, K_c) + P_M\, Mr(L_m, K_m)$,

where P_M and P_C denote the (constant) 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.

(4) $M_L/C_L = M_K/C_K = 1+\mu$.

or equivalently

$$(4') \qquad \frac{P_M Mr_L}{P_C Cr_L} = \frac{P_M Mr_K}{P_C Cr_K} = 1 + m. .$$

(4') serves to highlight the plain fact that comparisons of marginal factor productivities across different production sectors depend necessarily on the price relations used in the evaluation of sectoral outputs. In short, intersectoral factor productivity rankings are price-contingent[4].

Proportional differentiation of (3) with (1) and (2) yields the growth equation

$$(5) \quad \hat{Y} = \frac{C_L L}{Y}\hat{L} + C_K \frac{I}{Y} + \left(\frac{m}{1+m} + C_M\right)\frac{M}{Y}\hat{M} \; ,$$

where the 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, (5) can be restated in the form

$$(5') \quad \hat{Y} = \frac{C_L L}{Y}\hat{L} + C_K \frac{I}{Y} + \left(\frac{m}{1+m} - q\right)\frac{M}{Y}\hat{M} + q\hat{M} \; ,$$

[4] In other words: direct intersectoral comparisons of physical marginal factor products are evidently meaningless: are three guns per man-hour at the margin more than a ton of butter per man hour?

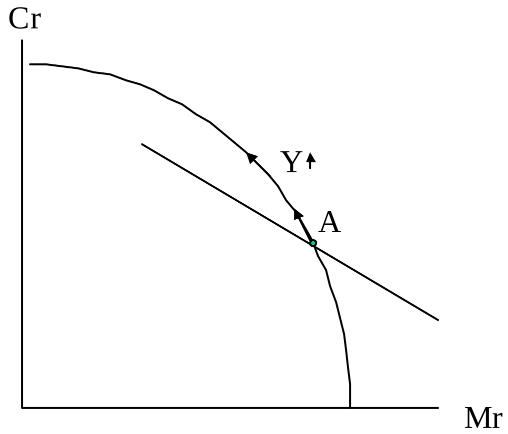
which permits - at least in principle - the separate identification of the externality effect and the "marginal factor productivity differential effect".

Variants of (5) and (5') 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], Antonakis[1999], Batchelor Dunne and Saal [2001]), and pooled cross-section time-series data (e.g. Alexander [1990], Murdoch et al.[1997]). While the practical econometric problems arising in these studies are frequently discussed in the literature, far less attention is paid to potential problems with the underlying theoretical basis and the theory-consistent interpretation of the empirical results. Sometimes it appears that the above-mentioned label "neoclassical" serves as a kind of quality stamp for theoretical rigour, which dispenses authors of the need for further justification of the theoretical rationale underlying the regression analysis. However, from the perspective of economic theory, a number of features of the analytical framework deserve closer scrutiny.

To begin with, the notion of a relative marginal factor productivity differential between sectors in (4) deserves a closer look (as it appears to be a source of interpretational pitfalls). In the empirical literature, a non-zero μ is customarily interpreted to reflect a situation where 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 afflicting that sector. For instance, in a pooled cross-section time-series analysis for nine industrialized countries, Alexander[1990:50] estimates μ=-0.88 and concludes "that the defence sector is 88% less productive than the 'rest' of the economy". Ward, Davis and Chan [1993] estimate a negative mu for Taiwan and conclude "that in comparison to the civilian sector..., the military sector is considerably less efficient". Sezgin[1997:404] comments his finding of a negative mu for Turkey: "It means that the civilian sector is more productive than the defence sector, because defence is less subject to the rigours of market discipline". Similarly Antonakis[1997:652n] paraphrasing Atesoglu and Mueller[1990:20]: "Without strong competitive pressure to induce ... efficiency in the management and use of resources, it can be argued that marginal factor productivities are lower in the defence sector". [5]

Such interpretations are not consistent with the underlying theoretical model. Although this point seems to have gone unnoticed in the literature, technical efficiency in production holds in the model by assumption: By imposing uniformity of the factor productivity differential for both factors via (4), studies based on the two-sector Feder-Ram model unwittingly assume that the economy produces on the efficient frontier of the production possibility set (e.g. point A in Figure 1).

Figure 1



$\mu<0$: P<MRT

In the present context, technical efficiency in production (which is reached when C production cannot be raised without giving up some M production or vice versa) requires the equalization of the marginal rates of technical substitution (MRTS) between labour and capital across production sectors. Since $MRTS_M = Mr_K/Mr_L$ and $MRTS_C = Cr_K/Cr_L$, the efficiency condition can be restated in the form $Mr_K/Mr_L = Cr_K/Cr_L$ which is equivalent to assumption (4').

[5] This list of illustrative quotations could be continued *ad lib*.(to any desired extent). See e.g. Huang and Mintz [1991:36], Alexander[1995: 14] Murdoch, Pi and Sandler [1997:209] among others.

The suggestion that a non-zero μ measures the presence of some sort of *sector-specific* inefficiency in the use of resources is flawed.[6] A non-zero μ arises whenever the price ratio $P = P_M/P_C$ used in the evaluation of real GDP deviates from the marginal rate of transformation (MRT) between C and M, which measures the amount of "butter" society must give up in order to produce another "gun". When P < MRT as in Figure 1a, $\mu<0$ and real GDP as calculated according to (3') would rise if resources are moved from military to civilian production, or vice versa if P>MRT and $\mu>0$ (Figure 1b). However, the GDP growth via factor re-allocation is *not* a result of shifting resources from a sector with inefficient intrasectoral resource management due to lacking competitive pressure to a sector with less organizational slack. In the case of Figure 1a, real GDP rises by moving resources from M to C, because in Point A the value of a unit of C in terms of M goods (1/P) used in the calculation of Y is higher than the social cost of producing another unit of C in terms of M (1/MRT). The question if such a resource move which raises measured real GDP is actually socially desirable cannot be answered without knowledge as to whether the relative price P used in the calculation of Y adequately reflects the social marginal rate of substitution, i.e. the rate at which "society" is willing to trade off M for C. If it does, a non-zero μ reflects a situation where the economy-wide product mix and thus the intersectoral factor allocation in the economy as a whole is inefficient, yet this has nothing to do with lacking effort or ability to transform inputs into outputs in the individual sectors.

4. Developing a Growth Model with Military Spending

The deficiencies of the Feder Ram model lead us to consider an alternative route. Specifically we develop a model of the effect of military spending on growth performance based on augmented Solow growth model with Harrod-neutral technical progress. This follows Knight, Loayza and Villanueva[1996;1993], which is in turn based on the approach of Mankiw, Romer and Weil [1992]. In this model the key assumption is that the military spending share m:= M/Y affects factor productivity via

[6] The potential counter-argument that the approach is supposed to capture some sort of off-the-production function behaviour is invalid. The production functions (1) which are used for the derivation of the empirical growth eqation (5) are specified for a given invariant level of intra-sectoral organizational (or "X"-) efficiency.

level effect on efficiency parameter which controls labour-augmenting technical change.

The starting point for the model is Starting point: aggregate neoclassical production function featuring labour-augmenting technological progress

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

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

(2) $$A(t) = A_o e^{gt} m(t)^{q}\ ,$$

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.

Together with standard Solow model assumptions (constant saving rate s; constant labour force growth rate n; constant rate of capital depreciation d), the dynamics of capital accumulation are described by

(3) $$\dot{k}_e = sk_e^{a} - (g+n+d)k_e \;\Leftrightarrow\; \frac{\partial \ln k_e}{\partial t} = se^{(a-1)\ln k_e} - (g+n+d)\,,$$

where k_e:=K/[AL] denotes the effective capital-labour ratio and α is the constant capital-output elasticity.

The steady-state level of k_e is

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

Linearizing (3) via a truncated Taylor series expansion around the steady state[7] and using (4), we get

The model is by construction incapable of accounting for intra-sectoral organizational inefficiencies.
[7] Re-writing (3) in the form du/dt = f(u), u:=ln ke, the linearized form is f(u*) + f'(u*)[u(t)-u*].

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

and since ln ye:= ln [Y/(AL)] = αln ke,

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

whereby the steady-state level of output per effective labour unit is

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

Equation (6) approximates the *transitory* dynamics of output per effective labour unit in a neighbourhood of the steady state. In order to operationalize (6) for empirical work, we integrate (6) forward from t-1 to t and get

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

Using (2), (7) and (8), ye is related to observable per capita income y:= Y/L via

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

Equation (9) suggests the dynamic panel data model

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

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};

ã=e^z>0, $â_1$=(1-e^z)á/(1-á)>0, $â_2$= -$â_1$<0, $â_3$=è, $â_4$= -e^zè = - ãâ$_3$, $ç_t$ = g(t-(t-1)e^z), $ì_i$ = (1-e^z)A_o.

Thus we follow Knight et al[1993] and Islam[1995] in treating s, n as variant 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[8].

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[8] this corresponds with Knight et al [1993:eq 9 for r=1, sh=beta=thetaf=0 P<=>m) and Islam[1995:eq.11].

This model can be augmented to deal with human capital. Following Mankiw, Romer and Weil(1992), human capital is introduced into the model by re-specifying the aggregate production function as[9]

(1') $Y(t) = K(t)^{a} H(t)^{b} [A(t)L(t)]^{1-a-b}$,

where H denotes the human capital stock.

Human capital per effective labour unit, h_e:= H/(AL), and physical capital per effective worker evolve according to

(11) $\dot{h}_e(t) = s_h y_e(t) - (n+g+d)h_e(t)$, $\dot{k}_e(t) = s_k y_e(t) - (n+g+d)k_e(t)$,

where s_h and s_k denote respectively the ratio of human and of physical capital investment to income, and human capital is assumed to depreciate at the same rate d as physical capital.

The steady-state capital stock levels are

(12) $k_e^* = \left[\dfrac{s_h^{b}\, s_k^{1-b}}{g+n+d}\right]^{1/(1-a-b)}$, $h_e^* = \left[\dfrac{s_h^{1-a}\, s_k^{a}}{g+n+d}\right]^{1/(1-a-b)}$.

Proceeding in similar fashion to the derivation of (6), the transitory dynamics of income per effective worker in a neighbourhood of the steady state are approximated by

(6') $\dfrac{\partial \ln y_e}{\partial t} = (\boldsymbol{a}+\boldsymbol{b}-1)(g+n+d)[\ln y_e(t) - \ln y_e^*]$,

and the equation for income per actual worker which provides the basis for the empirical analysis is now

[9] See Temple(2001:908) for some critical reflection on the plausibility of this specification.

(9')

$$\ln y(t) = e^{z} \ln y(t-1) + (1-e^{z})\left\{\ln A_o + \frac{\boldsymbol{a}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln s_k + \frac{\boldsymbol{b}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln s_h - \frac{\boldsymbol{a}+\boldsymbol{b}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln(n+g+d)]\right\}$$
$$+\boldsymbol{q}\ln m(t) - e^{z}\boldsymbol{q}\ln m(t-1) + (t-(t-1)e^{z})g$$

suggesting the dynamic panel model specification

(10’) $$\ln y_{i,t} = \boldsymbol{g}\ln y_{i,t-1} + \sum_{j=1}^{5}\boldsymbol{b}_j \ln x_{j,i,t} + \boldsymbol{h}_t + \boldsymbol{m}_i + \boldsymbol{n}$$

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 ã=e^z>0, $â_1$=(1-e^z)á/(1-á-â)>0, $â_2$= -($â_1$+$â_5$)<0, $â_3$=è, $â_4$= -e^zè = - ã$â_3$, $â_5$=(1-e^z)â/(1-á-â)>0, $ç_t$ = g(t-(t-1)e^z), $ì_i$ = (1-e^z)A_o.

These models have been developed explicitly to deal with panel data and the estimation methods available are discussed in the next section.

5. Estimation Methods

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 thing, the former the long run and the latter the short run effects. 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.

Panel data methods provide a variety of approaches to attempt to deal with some of these issues, with pooling the simplest form and fixed effect and random coefficient estimators providing more flexible approaches. The pooled OLS estimates:

(11) $y_{jt} = \boldsymbol{a} + \boldsymbol{b}\, x_{jt} + u_{jt}$

and assumes all parameters are the same for each country. The fixed effects estimator allows the intercept to differ across countries

(12) $y_{jt} = \boldsymbol{a}_j + \boldsymbol{b}\, x_{jt} + u_{jt}$

which ignores all information in the cross sectional relation. Time fixed effects can also be allowed for separately or together in a two way fixed effect model:

$$(13) \quad y_{jt} = \alpha_t + \alpha_j + \beta x_{jt} + u_{jt}$$

In dynamic models of the form:

$$(14) \quad y_{jt} = \alpha_j + \beta x_{jt} + \lambda x_{jt-1} + u_{jt}$$

the fixed effect estimator is not efficient, because of lagged dependent variable bias, which biases OLS downwards. It is, however, consistent and for samples of the size used here the bias is small. 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 (Pesaran and Smith, 1995)

6. Empirical Results: Feder Ram

To operationalise the model for empirical application the instantaneous rate of change of the variables are replaced by their discrete equivalents giving:

$$(15) \quad \Delta Y_t/Y_{t-1} = \alpha_0 + \alpha_1 \Delta L_t/L_{t-1} + \alpha_2 I_t/Y_{t-1} + \alpha_3 \Delta M_t/M_{t-1} (M_t/Y_{t-1}) + \alpha_4 \Delta M_t/M_{t-1}$$

The 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 OECD. In addition, there are data on military expenditure as a share of GDP from SIPRI. The sample consists of two groups:17 large 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).

Estimating this equation using the means for the 28 countries gave for the one and two way fixed effects and the Swamy random coefficient estimator:

Table 1: Feder Ram Results

	Expect	Fixed Effects One	Fixed Effects Two	RCM
$\Delta L_t/L_{t-1}$	+	0.074 (0.8)	0.147 (1.7)	0.149 (0.3)
I_t/Y_{t-1}	+	0.002 (1.1)	0.003 (2.2)	0.471 (2.7)
$\Delta M_t/M_{t-1}$ (M_t/Y_{t-1})	?	-0.072 (-0.7)	-0.008 (-1.5)	11.150 (0.1)
$\Delta M_t/M_{t-1}$	?	0.016 (1.8)	0.025 (2.9)	-0.161 (0.0)
t	+	-0.001 (-8.2)		-0.0005 (-0.8)
θ Size effect		0.016	0.025	-0.161
μ Externality		-1.112	0.017	

The one way fixed effects provide 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 (productivity differential 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 are very disappointing results and might lead us to consider expanding the model to introduce more sectors, as in Nikolaidou (2000) or to attempt to improve the dynamics, as in Birdi and Dunne (2001) we might be tempted to move to expanding the model. In this paper, however, our concerns over the nature of the model lead us to search for an alternative approach.

7. Empirical Results: New Growth model

To estimate the growth model developed from theory, we need to adjust for the fact that we do not have a human capital measure available and so estimate

$$(16) \qquad \ln y_{i,t} = \boldsymbol{g} \ln y_{i,t-1} + \sum_{j=1}^{5} \boldsymbol{b}_j \ln x_{j,i,t} + \boldsymbol{h}_t + \boldsymbol{m}_i + \boldsymbol{n}$$

where
$x_1 = i/y$
$x_2 = n + g + d$
$x_3 = m/y$
$x_4 = m/y_{t-1}$

From the development of the theory we have a number of expectations of the signs of the coefficients

$\gamma = e^z > 0$

and should be close to unity

$\beta_1 = (1-e^z)\alpha/ (1- \alpha) > 0$

$\beta_2 = - \beta_1 < 0$

$\beta_3 = \theta$

the coefficient on ln m_t productivity effect should be the opposite sign to β_3 and of similar magnitude as:

$\beta_4 = - e^z \theta = - \gamma\beta_3$

$\eta_t = g (t – (t-1) e^z)$

is the trend parameter, with the rate of technical progress assumed the same across all countries and

$\mu_I = (1- e^z) A_0$

are the country specific effects

Estimating the model on the pooled data gives the in Table 1 below, for one and two way fixed effects and the random coefficient models..

Table 2

	Fixed Effects One	Two	RCM
$\gamma = e^{z} > 0$	0.96	0.96	0.96
	(149)	(151)	(9.1)
$\beta_1 = (1-e^{z})\alpha / (1-\alpha) > 0$	0.04	0.04	0.11
	(8.8)	(9.2)	(2.7)
$\beta_2 = -\beta_1 < 0$	-0.05	-0.04	-0.14
	(-4.9)	(-4.8)	(-1.2)
$\beta_3 = \theta$	-0.04	-0.03	-0.06
	(-5.3)	(-3.5)	(-1.0)
$\beta_4 = -e^{z}\theta = -\gamma\beta_3$	0.03	0.02	0.06
	(3.7)	(2.9)	(1.2)
$\eta_t = g(t - (t-1)e^{z})$	0.27	-	0.01
	(1.5)		(2.4)
$\mu_i = (1-e^{z}) A_0$	-	-	-

These results provide estimates that are completely 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, while the coefficient on the investment share β_1 is positive and for the fixed effects model around 0.04. β_2 the coefficient on the labour force growth term 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. This reflects the productivity effect of military spending on growth and shows it to be consistently negative. β_4 should be the opposite sign to β_3 and of similar magnitude and it is, with significant estimates for the fixed effects models. The trend parameter η_t 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.

8. Conclusions

This paper has considered the theoretical and empirical issues involved in estimating growth models to investigate the impact of military spending. It suggests that the commonly used Feder Ram model has a number of weaknesses and misinterpretations and should not really be the main tool of such analyses. A useful alternative approach is found to be to take a simple neoclassical growth model and introduce an impact of military expenditure through its effect on technology. Another issue considered is use of panels of data, rather than simple cross sections on averages. Estimates were made of both the Feder Ram and the new growth model using one and two way fixed effects models and a Swamy random coefficient estimator. This produced poor results for the Feder Ram model, but much more promising results for the new growth model. The use of this model and of panel data methods for the relatively long time series available way have been shown to be a potentially important new development for research in the area.

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