OPTIMAL MILITARY SPENDING IN THE US: A TIME SERIES ANALYSIS

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Abstract

This paper extends previous work on the optimal size of government spending by including nested functional decompositions of military spending into consumption and investment. Post World War II US data are then used to estimate nested non-linear growth models using semiparametric methods. As expected, investment in military and non-military expenditure are both found to be productive expenditures. Moreover there is little evidence to suggest that current military spending is having a negative impact on economic growth in the US, while civilian consumption only tends to have only a weak impact. This does not imply that society will necessarily benefit from a reallocation of more spending to the military sector, nor that it is the best way to achieve economic growth. It does suggest that the US economy is not necessarily being hindered by its current military burden.

keywords:Economic growth; productive state spending; military spending, semi-parametric estimation

JEL: H50, O41, O47.

1 Introduction

The economic impact of military spending on economic growth remains an important and compelling debate, with no clear consensus emerging (Dunne and Uye, 2009; Dunne, 2005; Smith, 2000).While the literature has covered a range of macroeconomic issues there has been little concern over the issues raised in Devarjan et al (1996) of the impact of government consumption spending and its components and the possibility of an 'optimal' level of military spending (in terms of its impact on economic growth) suggested by nonlinear endogenous growth models. Using US data for the post World War II period this paper provides just such an analysis. It takes the (nonlinear) endogenous growth model proposed by Barro (1990) and develops it to analyse the response of economic growth to changes in the mix of government expenditure and the individual components. The theoretical framework is developed by assuming the functional components of expenditure (namely, military, health, infrastructure etc.) and the macro-aggregates consumption and investment are "productive", while the components of government spending are not "productive" in nature. Mittnik and Neumann (2003) analyzing the German economy in the post second world war suggested that *a priori* assumptions of 'unproductive' and 'productive' government spending between consumption and investment may lead to misleading results, so this paper attempts to investigate these properties empirically with particular attention to the effect of military spending.

In the empirical literature a major finding is that output growth is negatively correlated with the share of government consumption in GDP, while is positively correlated with the share of government investment [1]. Thus, in this paper a disaggregated approach is used to evaluate the impact in the economy of the allocation of government budget between consumption and investment within the functional components of military and non-military spending. Some basic questions are then asked: from a fiscal policy standpoint, how much should the nation spend on military (and non-military) sector, how should consumption and investment expenditure of the previous functional categories be allocated within the public sector and what is (if it exists) the time path that leads to an optimal size allocation?

The key empirical problem is, therefore, to combine the empirical observation with the theoretical framework by postulating a model that introduces the size of the functional government expenditures into the Barro (1990) model and examining how the allocation influences the results. Devarajan et al. (1996) proposed such an extension for a specific functional classification of government spending, comparing the impacts on the growth rate of developed and developing countries. This is further developed to focus on the effects of military and non-military components of government spending, with an even more disaggregated model being developed to distinguish consumption and investment expenditures with in the functional categories. In the next section the analytical framework is developed to link the composition of public spending with economic growth and to determine the nature of the growth model required to assess the effects of military (or non-military) spending. Restricted versions of this model, that only consider the consumption and investment

[1] Aschauer (1989), Barro (1990) were the pioneers that theoretically and empirically highlight the effects of productive and unproductive government spending.

categories of government spending are also developed. Section 3 then presents the empirical analysis using a state-dependent (state-varying) model and providing an interpretation of the results[2]. Finally, section 4 presents some conclusions.

2 Conceptual Framework

To develop a theoretical model the existence of a non-monotonic relationship between growth and government size is assumed and productive government spending and its components are introduced into an aggregate production function. A baseline a version of Barro (1990) is used to characterize a number of broad principles with an optimal government size that maximizes economic growth. Using the constant elasticity of substitution (CES)[3] aggregate production function gives:

$$y = \left[\alpha k^{-\zeta} + \beta g_1^{-\zeta}\right]^{-\frac{1}{\zeta}} \tag{1}$$

That is commodity production, y, is a function of private capital stock, k, and aggregate government spending, g_1 . For this production function, g_1 provides a unique productive good that is assumed to be a non-perfect substitute for the private input. The growth equation for private capital needs to be satisfied:

$$\dot{k} = (1-\tau)\left[\alpha k^{-\zeta} + \beta g_1^{-\zeta}\right]^{-\frac{1}{\zeta}} - c \tag{2}$$

[2]See Jones (1995) and **?** for an extended analysis of linearity tests in endogenous growth models.

[3]This functional form is a general theoretical framework. In fact, the CES function includes as special case the Cobb-Douglas though, with respect to this production function, allows for a larger degree of substitutability between inputs.

where $\dot{k}$ denotes growth of private capital changes over time, τ the flat rate income tax and c the consumption level of households. A representative agent then assumed to choose consumption, c, and capital, k, to maximize the future instantaneous utilities:

$$U = \int u(c)e{-}\rho t \tag{3}$$

where ρ is the rate of time preference and the conventional positive but diminishing marginal returns to consumption is imposed by the following inequalities:

$$u'(c) \geq 0, \quad u''(c) \leq 0 \tag{4}$$

As is common in the literature an isoelastic utility function:

$$u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \tag{5}$$

in which σ is the intertemporal elasticity of substitution of consumption. Let τ, the flat-rate income tax necessary to finance public sector, be defined as follows:

$$\tau = \frac{g_1}{y} \tag{6}$$

To evaluate the impact of g_1 on economic growth, we use the following equality, which has to be satisfied at the steady-state:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\theta}\left((1 - \tau)y' - \rho\right) \tag{7}$$

Formally, the model is solved by substituting (5) into (3), and maximizing subject to (2) giving:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\theta}\left[(1-\tau)\alpha^{-1/\zeta}\left[\frac{\left(1-\tau\beta^{-1/\zeta}\right)^{(1+\zeta)} + \beta^{-(1+\zeta)/\zeta}\tau^{1+\zeta}}{\left(1-\tau\beta^{-1/\zeta}\right)^{1+\zeta}}\right] - \rho\right] \tag{8}$$

This gives a standard endogenous growth model in which the dependent variable is a non-linear function of τ and the effect of the public sector depends on the amount of resources allocated by the government to finance it and by the productivity parameter of government spending, β. That is, the optimal level of the share of government in GDP occurs at the point where the flate-rate income tax, τ, exactly equals the marginal effect of τ Barro (1990), Shieh et al. (2002), Cuaresma and Reitschuler (2004).

To analyse the military and non-military components of the public budget sector within this endogenous growth framework, the Devarajan et al. (1996) baseline model, which accounts for the size of the categories in government spending, provides a starting point. Central government is assumed to decide the allocation of expenditure within its components and after that to decide the overall share of total government spending in GDP. This seems a reasonable assumption for government behaviour and provides an additive property that enables the marginal effects of changes in the allocation of government spending to be determined.

In addition, simple manipulation of the government budget constraint gives the size of the military (and alternatively for non-military) sector that provide the highest economic growth. Taking:

$$g_1 = g_2 + g_3 = \tau y \tag{9}$$

where g_1 and g_2 identify the components of government spending for military and non-military, respectively and ϕ and $(1-\phi)$ their shares of total expenditure. The flows of government spending are:

$$g_1 = \phi \tau y \tag{10}$$

$$g_2 = (1-\phi)\tau y \tag{11}$$

and combining this with the aggregate production function gives:

$$y = \left[\alpha k^{-\zeta} + \beta g_2^{-\zeta} + \delta g_3^{-\zeta}\right]^{-\frac{1}{\zeta}}, \tag{12}$$

with the modified motion equation for private capital,

$$\dot{k} = (1-\tau)\left[\alpha k^{-\zeta} + \beta g_1^{-\zeta} + \delta g_2^{-\zeta}\right]^{-\frac{1}{\zeta}} - c \tag{13}$$

gives the growth rate of consumption (and economic growth rate) which after rearranging is:

$$\gamma = \frac{1}{\theta}\left[\frac{(1-\tau)\alpha}{\left[\alpha\tau^{\zeta}/(\tau^{\zeta} - \beta\phi^{-\zeta} - \delta(1-\phi)^{-\zeta})^{(1+\zeta)/\zeta}\right]}\right] \tag{14}$$

The growth equation (14) depends on the flat-rate income tax τ and on the share of resources allocated to each functional component of government spending, maintaining the non-linearity that is common to this class of endogenous models. Differentiating this expression with respect to ϕ (the share of military spending in GDP) with $0 < \phi < 1$ means that:

$$\frac{\phi}{(1-\phi)} < \left(\frac{\beta}{\delta}\right)^{(1-\zeta)/\zeta} \implies \frac{d\gamma}{d\phi} > 0 \tag{15}$$

$$\frac{\phi}{(1-\phi)} > \left(\frac{\beta}{\delta}\right)^{(1-\zeta)/\zeta} \implies \frac{d\gamma}{d\phi} < 0 \tag{16}$$

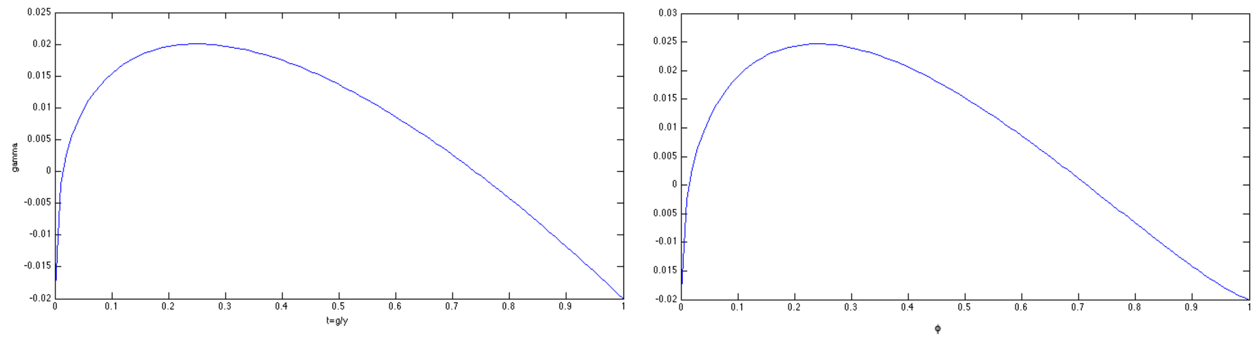
which is consistent with the Devarajan et al. (1996) baseline model and implies that the impact of the share of military spending on growth depends jointly on the productivity parameters, β and δ relative to their initial share. Thus, if the actual proportion ϕ is higher than its optimal level with respect to the relative output elasticity, β and δ, a negative impact on growth is expected and vice-versa for small levels of ϕ.

Figure 1 compares simulations of the theoretical relationships of the Devarajan et al. (1996) model to the Barro (1990) model in a nested Cobb-Douglas specification and shows an inverse hump-shaped path. This implies that there exists an optimal size of government spending, one that maximizes economic growth. While the growth rate function reflects the specificity of the production and utility functions, with the maximum depending on the parameter values, it is clear that the non-linearity is a common feature of these models.

The framework is then extended by assuming that the supply-side channels of (productive) military spending can give different outcomes, when the functional categories of government consumption and investment are incorporated. Previous analyses of the economic impact of government spending have generally assumed (and verified) that public (physical and human) investment represents a productive component, while consumption expenditure has generally been hypothesized as an unproductive. This was questioned by Devarajan et al. (1996) who showed that changes in the composition of government spending towards consumption expenditure may in fact lead to higher steady state growth. In addition, it seems reasonable to argue that specific components of consumption spending will be productive. In particular, military spending may have an impact through improving national security and increases in external threats may well produce increases in the level of military expenditure and its share of total government spending.

There are also some suggestions in the literature that increased security may increase economic productivity, through externality effects, and may be a source of nonlinearity. This is not to say that military spending is more productive than other forms of expenditure, but it does suggest it is reasonable to consider military consumption expenditure as potentially productive Dunne and Uye (2009). Exactly what its impact on private output, productivity and economic growth is, of course, an empirical issue and one that can be addressed using equation (14). Starting with the flexible Devarajan's framework, government spending is allocated to military consumption expenditure and a residual category of government spending, i.e. non-military and military investment spending. The analysis is then repeated using military investment expenditure, with military consumption and non-military expenditures comprising the residual category.

Figure 1: Specification of the endogenous growth models



Notes: graph 1a. adopts: $\rho = 0.02, A^{1/\beta}, \alpha = 0.75, \beta = 0.75$, graph 1b. adopts: $\rho = 0.02, A^{1/\beta}, \alpha = 0.75, \beta = 0.05, \delta = 0.20, \tau = 0.22$

3 Empirical Analysis

3.1 Data and Methodological Issues

For the empirical analysis quarterly US data for the period $1958:1-2005:1$ is used to estimate the endogenous growth models. The government consumption expenditure variable (gov), used in Barro's model, is broken up into military (mil) and civilian spending ($nonmil$), then these are further disaggregated into consumption and investment. This gives military consumption (mil_c) and military investment (mil_i); non-military consumption ($nonmil_c$) and non-military investment ($nonmil_i$). Output is measured by GDP (at constant and current prices) and gross fixed capital formation is used as a measure for private investment. The main sources are the International Financial Statistics (IFS) database, which reports U.S. National Income and Product Accounts (NIPA). For estimation, the constant price GDP growth rate (γ) and the share of the investment in GDP (inv) were computed and fitted values of the investment share computed using an auxiliary regression on lagged investment growth, to deal with potential endogeneity Jones (1995).

Table 1: Specifications of endogenous growth models

Endogenous growth models	Production function	Empirical measures of government spending
$Barro's(1990)\ model$	$y = \left[\alpha k^{-\zeta} + \beta g_{1t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Total government consumption in GDP $g_{1t} = gov/gdp$
$Devarajan's(1996)\ baseline\ model$	$y = \left[\alpha k^{-\zeta} + \beta g_{2t}^{-\zeta} + \delta R_{1t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of military spending in GDP $g_{2t} = mil/gdp, \quad R_{1t} = nonmil/gdp$
	$y = \left[\alpha k^{-\zeta} + \beta g_{3t}^{-\zeta} + \delta R_{2t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of Non-military spending in GDP $g_{3t} = nonmil/gdp, \quad R_{2t} = mil/gdp$
$Modified\ benchmark\ models$	$y = \left[\alpha k^{-\zeta} + \beta g_{4t}^{-\zeta} + \delta R_{3t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of military consumption in GDP $g_{4t} = mil_c/gdp, \quad R_{3t} = (nonmil + mil_i)/gdp$
	$y = \left[\alpha k^{-\zeta} + \beta g_{5t}^{-\zeta} + \delta R_{4t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of military investment in GDP $g_{5t} = mil_i/gdp, \quad R_{4t} = (nonmil + mil_c)/gdp$
	$y = \left[\alpha k^{-\zeta} + \beta g_{6t}^{-\zeta} + \delta R_{5t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of Non-military consumption in GDP $g_{6t} = nonmil_c/gdp$, $R_{5t} = (mil + nonmil_i)/gdp$
	$y = \left[\alpha k^{-\zeta} + \beta g_{7t}^{-\zeta} + \delta R_{6t}^{-\zeta}\right]^{-\frac{1}{\zeta}}$	Share of Non-military investment in GDP $g_{7t} = nonmil_i/gdp$, $R_{6t} = (mil + nonmil_c)/gdp$

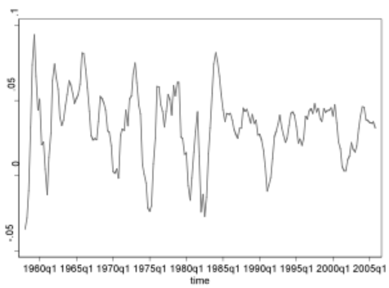
The specifications for the endogenous growth models are presented in Table 1, together with their corresponding production function and the government spending variables they include. It is worth noting that disaggregating the government components of the theoretical model is achieved by using the particular expenditure component with another residual component, but that both, are modelled to have potential productive impact on economic growth.

Figure 2 presents the government spending shares in GDP over time. Panels (c)-(f), show decreasing trends in the shares of total and military spending, particularly in the 1960s, while, in contrast, the share of civilian government spending shows a positive trend initially, tailing off in the late 70s, with a sharp decrease in 'non-military public investment'. Finally, although military consumption in the U.S. appears to be event-driven with large cyclical spikes corresponding to wars (or the threat of war) (Gerace, 2002; Gold, 2005), there is a clear pattern of decline over the period.

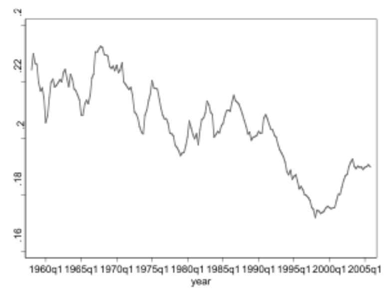
3.2 Econometric specification

In developing the econometric specification, Figure 1 suggests that a good starting point is to test for the presence of non-linearities in the growth equation. As Mittnik and Neumann (2003) point out, this avoids specification problems in the linear model that might result from variations in government size. In line with the simulation results, the presence of two regimes is assumed, one with low shares of government spending in GDP and a positive impact of that spending on growth and the other with high shares and a negative effect. To shed light on the empirical relationships, the linear model is tested against a smooth transition autoregressive (STAR) model. This strategy provides objective guidelines for choosing the appropriate (non)linear model (Cai et al. 2004; Chen, 1993; Tong, 1990; Granger and Teräsvirta, 1993) and as the STAR belongs to the family of functional autoregressive (FAR) model,

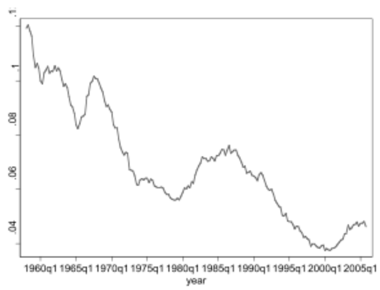
Figure 2: Time-series plots of GDP growth rate, the share of government spending and its components in GDP



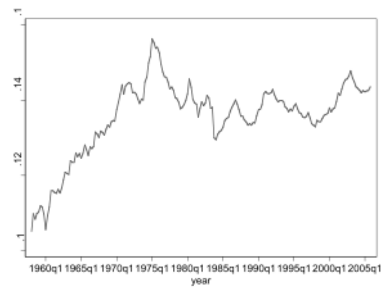
(a) GDP growth rate



(b) Government spending



(c) Military



(d) Non-military

(e) Military consumption

(f) Military investment

(g) Non-military consumption

(h) Non-military investment

these models can be used to estimate the coefficients of the relationship between government expenditure and economic growth using semi-parametric methods.

Taking a general nonlinear function of the continuous transition variable s_t gives:

$$(17) \qquad y_t = \phi' z_t + \theta' z_t G(\eta, c, s_t) + u_t \quad with \quad u_t \sim iid(0, \sigma^2)$$

where z_t is a vector of explanatory variables and $\phi = (\phi_0, \phi_1...., \phi_m)'$ and $\theta = (\theta_0, \theta_1...., \theta_m)$ are $((m+1)x1)$ parameter vectors of the linear and nonlinear part of the model, respectively. The transition function $G(.)$ is a bounded function of the continuous transition variable s_t, the slope parameter η and the vector of location parameters, $c = (c_1, ...c_k)$. Following Kratzig and Lutkepohl (2004), a sequential strategy for testing nonlinearity of the function is derived using the logistic smooth transition (LSTR) model. A third-order Taylor expansion around the hypothesis $\eta = 0$ means the following specifications can be identified:

$a)$ asymmetric behaviour in the hypothesized relationship (i.e. one change in the growth-government spending function, model LSTR(1));

$b)$ a process with heterogeneous dynamic properties between both large and small values of and central values (model LSTR(2));

$c)$ an Exponential Autoregressive model (EXPAR), an alternative of LSTR(2) when η is not close to zero Granger and Teräsvirta (1993).

The assumption of additive government expenditure components in the theoretical model means the share of government spending in GDP can be used as the predetermined transition variable. Methodologically, this implies distinguishing between two different cases depending on the inclusion or exclusion of the transition variable from z_t . When the nonlinear relationship uses total government spending (Barro's model in Table 1), the transition variable is incorporated in z_t, giving the auxiliary regression:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' \tilde{z}_t s_t^j + u_t^* \tag{18}$$

where the parameterization yields a vector $z_t = (1, \tilde{z}_t)$, in which $\tilde{z}_t$ is a $(mx1)$, and $u_t^* = u_t + R_3(\eta, c, s_t)\theta' z_t$ where the remainder is $R_3(\eta, c, s_t)$. For the other growth model specifications the size of the total government spending in GDP transition variable is not an element of z_t and the empirical specification is given as:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' z_t s_t^j + u_t^* \tag{19}$$

The null hypothesis of linearity $\beta_1 = \beta_2 = \beta_3 = 0$ is then tested against the alternative hypotheses shown in Table 2 using the strategy described above. The nonlinear model yields one choice among the available nonlinear specifications, however, so discriminating between the models is based on the strength of rejection, as measured by the p-value. If the test gives the strongest rejection the efficient nonlinear models have to be LSTR(2) or EXPAR specifications, while if the p-value is greater than the usual 5% or 10% the LSTR(1) model is accepted.

Under the maintained nonlinear hypothesis of a model with one transition variable and one regime change, a dynamic model can be estimated by defining z_t as a vector that includes the lagged values (p) of the endogenous and exogenous vari-

Table 2: Summary of hypothesis test.

$H_{01} : \beta_1 = \beta_2 = \beta_3 = 0$	Linear model selection.
$H_{02} : \beta_1 = 0 \vert \beta_2 = \beta_3 = 0$	$LSTR(1)$ with one transition variable and one regime change.
$H_{03} : \beta_1 = 0 \vert \beta_2 = 0$	$LSTR(2)$ with one transition variable and two regime changes.
$H_{04} : \beta_3 = 0$	$EXPAR$ where transition states are more than two.

ables:

$$z_t = \left(1, \gamma_{t-h}, inv_t, g_{it-h}, R_{jt-h}\right)$$

with γ_{t-h} the lagged GDP growth rates, inv_t the fitted share of private investment in GDP, g_{it-h} the share of productive government spending in GDP and R_{jt-h} the residual component:

$$\begin{aligned} \gamma_t &= a_0 + a_1\gamma_{t-1} + \ldots.. + a_p\gamma_{t-p} + d_1 inv_t + b_1 g_{it-1}(g_{1t}) \\ &+ \ldots.. + b_p g_{it-p}(g_{1t}) + c_1 R_{jt-1}(g_{it}) + \ldots\ldots. + c_p R_{jt-p}(g_{it}) \end{aligned} \tag{20}$$

It is worth noting that this is an extension of an AR model, where the coefficients vary according to the transition variable g_{1t}. The structure of (18) allows the long run effects of a change in total government expenditure, or a specific component, to be estimated using a recursive algorithm. The state dependent coefficients in (18) are estimated using semi-parametric moving window least squares (MWLS), a procedure that optimizes the window length (w) and reduces small sample statistical problems (Granger and Teräsvirta, 1993). Extending the endogenous growth model proposed by Jones (1995), **?**, Mittnik and Neumann (2003), means that a measure of the long-run impact of public spending on growth can be obtained by summing the coefficients of the nonlinear model[4] .

3.3 Estimation and tests

Rejecting the hypothesis of non-stationary is a necessary condition for testing a linear endogenous growth model against a non-linear specification (Kratzig and Lutkepohl, 2004), so before estimating the models the time series properties of the growth equation variables are investigated using unit root tests. However, in the case of non-linear time series, the conventional unit root tests only represent necessary, not sufficient, conditions for stationary [5]. It is also worth noting that the generally low power of these tests becomes practically nil for variables constrained to lie between zero and one.

Appendix 1 reports the results of augmented Dickey and Fuller tests for the variables in the endogenous growth model. Using flexible specifications, the only variable that does not reject non-stationary at the usual significance level is the share of private investment in GDP. Private investment *(inv)* is the most volatile component so, following Mittnik and Neumann (2003), the growth rate of investment is included in the model to account for the cyclical fluctuations. While the test value

[4] Algebrically: $LR(g_{it-1} = b/1 - a)$, where $b = \sum_{l=1}^{p} b_l$ is the sum of the coefficients relative to lagged values of the endogenous variable and $a = \sum_{l=1}^{p} a_l$ is the sum of the coefficients relative to lagged values of a share of government spending, while (g_{it-1}) is the assumed state variable.

[5] It is necessary to introduce supplementary requirements for a (complete) stationary of time series in nonlinear model: a) the generating mechanism is time invariant for each finite sub-sample of the time-series; b) the time series have a short-memory (Granger and Teräsvirta, 1993).

for share of the total government spending exceeds the 5% significance level, it is not above 10% one, rejecting the hypothesis of non stationarity for this variable is justified. Having established stationarity, the strategy described in section 3 is used to investigate the non-linearity properties of the seven different specifications. Choosing a lag length of 4 periods for both the endogenous and exogenous variables in equation (18), gave the results in Table 3. In line with theoretical expectations, there is a strong evidence for the presence of non-linearity. Indeed, the null hypothesis of linearity (H_{01} hypothesis) can be rejected in favour of the alternative hypothesis for every specification. Within the group of non-linear specifications, the LSTR(1) specification is always selected , as linearity is rejected most strongly for this form of non-linear model (H_{02} hypothesis).

Starting with the first model in Table 1 (Barro's model) each model is estimated using the state-varying parameter method described above, maintaining the same window length ($w = 80$) and lag lengths ($p = 4$). Anticipating that this might not be enough for models for military consumption and investment, the window length is extended ($w = 120$). In fact, though the results (estimations and tests) are generally robust to different window lengths, when the the effects of the components of expenditure on economic growth are considered, the greater variability in the data may be better handled (smoothed) by an increased window length (Granger and Teräsvirta, 1993).

The U.S. estimation results for the Barro model are plotted in Figure 3, which shows the overall long run effect of changes in government spending on GDP (y axis)

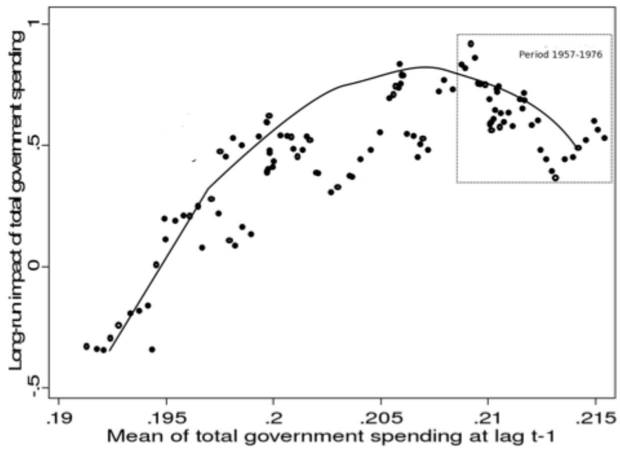
Table 3: Non-linearity F-tests for model specification ($p - values$).

Specifications of government components in the endogenous growth model	H_{01}	H_{04}	H_{03}	H_{02}
Share of total government spending in GDP	$7.38e-44$	0.61∗	0.79∗	$1.04e-52$
Share of military spending in GDP	$1.60e-36$	0.86∗	0.75∗	$4.69e-45$
Share of non-military spending in GDP **	$1.60e-36$	0.86∗	0.75∗	$4.69e-45$
Share of military consumption in GDP	$2.17e-31$	0.88∗	0.97∗	$6.80e-41$
Share of military investment in GDP	$3.21e-37$	0.86∗	0.41∗	$2.87e-45$
Share of non-military consumption in GDP	$1.40e-33$	0.23∗	0.067∗	$1.04e-38$
Share of non-military investment in GDP	$1.44e-37$	0.97∗	0.76∗	$1.58e-46$

Note: In this Table are reported the p-values of F-sequential non-linear tests. The asterisks (∗) show that the linearity hypothesis tests are not rejected at the 5% level. The suggested models are coherent with one transition variable and one regimeÕs change $LSTR(1)$, as specified in the $Table2$. ∗∗ Coherently with the non-linear models of the $Table1$, we report the values of the specification where the government component is the share of non-military spending in GDP. Because we use as transition variable the share of total government, the addictive condition with the share of military spending in GDP determines the same $F - test$ results of the $model2$.

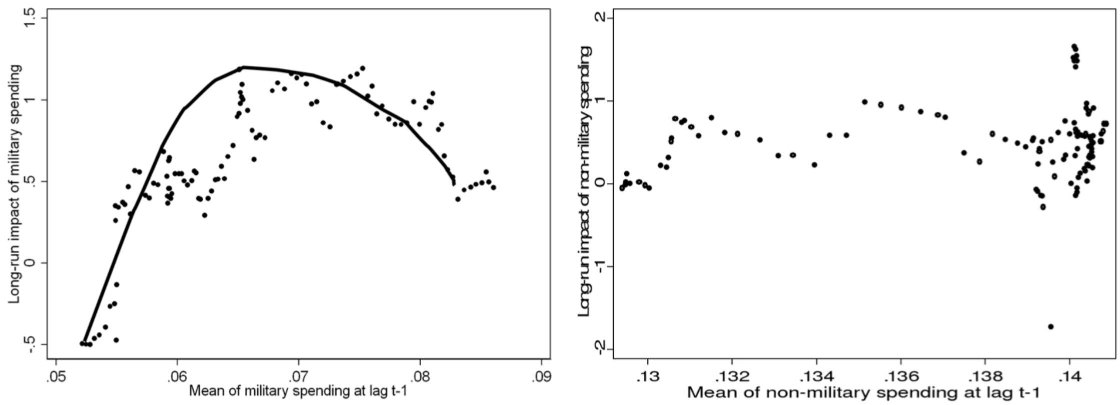
against the average of the state variable g_{it} at time $t-1$, that is $M(g_{it}) = \sum_{v=s}^{s+w-1} x_{iv}$ with $s = 1, ...T - w$. This shows the shape of the relationship to be consistent with the theory. To obtain the graphs below we will follow the same procedure.

Figure 3: Long-run effects implied by Barro's (1990) model.



These results suggest an optimal size for total government spending in the US of around 0.205-0.21 of GDP, with a non-linear response when this share of GDP is exceeded. It seems clear from Figure 2(b) that an excessive share of government spending in the period up to the first oil shock generated a negative relationship between government spending and economic growth, which then changed to a positive one, with the magnitude of the subsequent decrease in the share sufficiently large for the relationship to be positive overall. As expected, when government spending is broken down into military and non-military components, in line with Devarajan et al. (1996)'s baseline model, the different components of expenditure have differing effects on the long run growth of the U.S. economy. Thus the individual components of government spending need not exhibit persistent effects on economic growth even if aggregate public expenditure does. (Jones, 1995).

Figure 4: Long-run effects implied by the Deverajan's (1996) baseline model



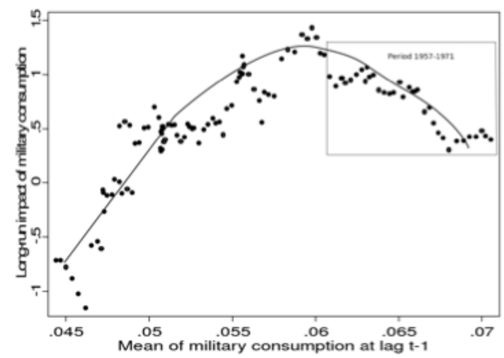
The share of military spending in GDP, gives a hump backed shape similar to that for total government spending, suggesting that the long run effect of military spending increases up to around 0.065 of GDP and declines after that, though from the graph the share of military spending does appear to be event-driven. In Figure 2, the long run pattern showed a clear trend decline, though with some movement, while Figure 4 suggests that there was a break point at the beginning of the 1970s, with the slope of the growth rate function changing from negative to positive.

This calls into question the implicit prediction that the a re-allocation of the share of civilian expenditure would significantly affect growth rates (Ramey and Shapiro, 1999). On the other hand, Figure 4b reveals that civilian spending may be classified as an unproductive component of government expenditure though on careful inspection the graph may also suggest a slight positive and constant effect with a cluster of observations being the high share of non-miltary spending and high effects. To consider whether military (and non military) components can be classified as productive or not, Figure 5 presents the long run effects of the estimated modified benchmark models. Figures 5a and 5b show the patterns of military consumption and investment to be in line with the predictions of the endogenous growth models. In both cases, significant non-linearities are found with an optimal size around $0.055 - 0.06$ and 0.01 for consumption and investment, respectively. However, different explanations are proposed for justifying the magnitude of the optimal size of expenditure.

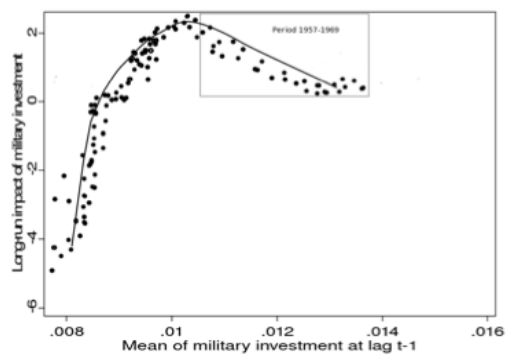
The observation of high substitution effects of military spending in investment affects the results in two ways. Firstly, the decline of this functional component produced a transitory rise in non-military investment that did not generate a long run optimal growth rate because simultaneously the U.S. economy experienced a reduction of overall government spending on investment. This implies that the amount of public non-military investment was below its optimum value, as shown by the existence of a monotonic increasing relationship between this component of expenditure and the GDP growth rate. Secondly, the re-allocative effects in investment for each functional category of government expenditure, has been sustained by the strong increases in expenditure on Medical care, which seems to have generated a short run stimulus for private investment with a limited retroactive effect on public investment (Pieroni, 2008). On the other hand, the pattern of military consumption expenditure is likely to have increased its marginal productivity, linked with a sharp rise of the demand for security from U.S. citizens, so that a positive impact on economic growth is not surprising, independent of the share of military spending in GDP.

The hypothesis of a non-linear relationship is not supported for the relationship between non-military consumption and economic growth, suggesting this component does not represent a good proxy for productive public spending. This result is in line with cross-country empirical analyses by Devarajan et al. (1996) and Kneller et al. (1999) indicates that industrialized countries have generally been misallocating public spending by favouring public consumption over public investment.

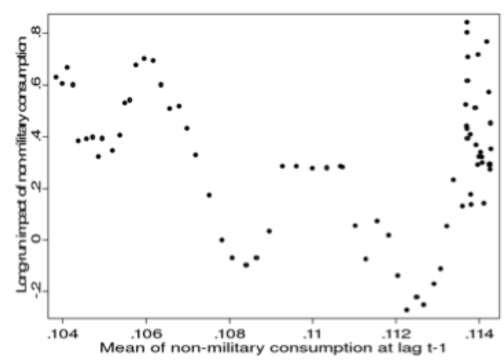
Figure 5: Long-run effects implied by the modified model



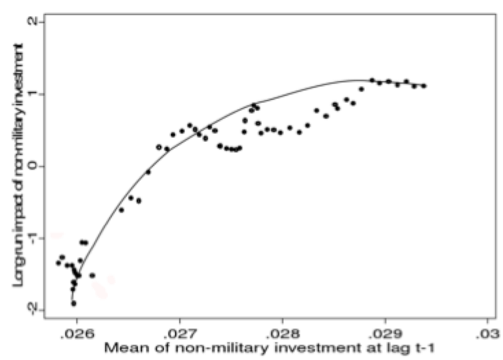
(a) dep. variable: Military consumption



(b) dep. variable: Military investment



(c) dep. variable: Non-military consumption



(d) dep. variable: Non-military investment

4 Concluding remarks

The effect of military spending on economic growth has been the subject of considerable debate, wit the declines that took place at the end of the Cold War and the present day pressures to increase expenditures. Within this research there is very little work that considers the changes in military burden within the context of the composition of overall government spending. The results for the post war US economy show clear differences in the impact of the different components of government spending and support the findings of Devarajan et al. (1996) that the classification of government current expenditure as unproductive and investment expenditures as productive is not necessarily adequate. Specifically, the results show that including categories of military and non-military spending in an endogenous growth model leads to the conclusion that military spending is productive, while non-military component does not significantly effect economic growth. While for military spending we find evidence of the hump-shaped models for consumption and investment found for total expenditure, current non-military government expenditure does not significantly affect economic growth. This suggests that the past bias in favour of investment expenditures for growth may indeed be misplaced.

These findings suggest that for the US economy and in the context of an endogenous growth model military consumption and investment can play a productive role in the economy. This does not mean that society will necessarily benefit from reallocation to military spending as government spending has many goals in society and economy. Nor does it mean that military spending is the best way to achieve economic growth. It does suggest, however, that the US economy is not necessarily being hindered by its current military burden, but that further increases are likely to be at the cost of economic growth in the long run.

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Appendix A: Dickey-Fuller test

Table 4: Dickey-Fuller Test

Variable	Test statistics	$P-value$
g	-4.517	0.0002
$inv*$	-1.587	0.4900
$g*$	-1.739	0.0910
g_1	-2.631	0.0046
g_2	-3.068	0.0290
g_3	-2.465	0.0073
g_4	-1.846	0.0332
g_5	-3.203	0.0198
g_6	-1.691	0.0462

notes: The results are obtained with optimal lags and with or without presence of deterministic trends. Their robustness is then checked by Dickey-Fuller GLS test.

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