

# Military Expenditure, Investment and Growth

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## **Abstract**

This paper considers the issues involved in estimating the effect of military expenditure on growth and the reasons for the lack of consensus in the literature. It briefly reviews the economic theory, emphasising the difficult identification issues involved in determining the interaction between military expenditure and output and discusses econometric methods for panels. It then takes advantage of the extended SIPRI military spending to construct a relatively large balanced panel of countries for the period 1960-2014. Rather than the usual focus on the direct relation between military spending on growth, it focusses upon the investment channel. It provides estimates of various models examining the interaction between the three variables and finds that the data do not suggest any strong relations between military expenditure and either investment or growth. This is not unexpected given the theoretical and econometric problems identified.

# 1 Introduction

The effect of military expenditure on growth has been an issue of concern to those interested in the economics of defence, since at least Benoit (1973). Benoit seemed to find a positive effect of the share of military expenditure on growth, but subsequent work did not confirm this relationship. The large subsequent literature did not seem to indicate any robust empirical regularity, positive or negative. Alptekin and Levine (2012) provide a meta-analysis of number of studies and suggest that there may be a positive effect, while Yesilyurt and Yesilyurt (2019) in a more recent meta analysis find evidence consistent with their hypothesis of no effect. In contrast, Dunne and Tian (2016) in a comprehensive survey of the literature argue that the effect is likely to be negative in studies that include post Cold War data.<sup>1</sup> With the growth in the literature a number of issues that might lead one to expect a heterogeneity of findings have had little attention.

The literature has tended to focus on the direct link between military spending and growth and the possible channels of influence are seldom considered. This might reflect the fact that there is no agreed theory of economic growth, though typically it is explained through a production function where it depends on the growth in: material inputs, labour, capital and sometimes also land and other natural resources; technology, perhaps measured by total factor productivity; and utilisation, including Keynesian demand stimulus effects, Dunne et al, 2005. Estimation faces difficult identification problems because the two-way causality between output and military expenditure can produce either positive or negative correlations between them. Thus interpreting whether the estimates are picking up a demand for military expenditure function, where military expenditure responds to output, or a supply side effect where military expenditure effects output growth raises difficulties. A further difficulty is that we are trying to measure the effects of quite small changes in military expenditure, which is itself usually a quite small share of output. It only tends to be a large share of GDP in times of war when there are many other influences on growth. In normal times one has to separate these small effects of military expenditure from all the other factors that influence variations in the growth rate. Finally, given we are trying to estimate a small effect, so the estimate is likely to be sensitive to the data em-

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<sup>1</sup>More general issues on the ‘peace dividend’, including the short-term effects of military expenditure on output, are surveyed in Gleditsch et al. (1996) and Chan (1995).

ployed (time-series, cross-section or panel; the countries and the time period considered), the econometric methods used and the specification adopted (Dunne, Smith and Willenbockel, 2005).<sup>2</sup> Fortunately, there now exists an extended military spending dataset from the Stockholm International Peace Research Institute (SIPRI) which provides longer series than were available for previous research and allowed a relatively large N large T balanced panel, of 46 countries for the period 1960-1997, to be constructed for this analysis (Perlo-Freeman and Skons; Perlo-Freeman, 2017)

This paper will review these issues and, rather than focusing on the direct effect of military spending on growth, will emphasise the link from military expenditure to growth through growth in capital stock determined by investment. Smith (1977,1980) are early studies of the association between investment and military spending, more recent contributions are Dunne et al (2002), Malizard (2015) and Kollias and Paleologou (2016). Section 2 uses a standard growth model to examine the economic and security dimensions of the relationship between military expenditure, investment and growth and considers what the system implies for what we might observe. Section 3 discusses the estimation issues in panel data models. Section 4 presents estimates for a panel and subpanels of countries over the period 1960-2014. Section 5 presents some some conclusions.

## 2 Theory

### 2.1 Military Expenditure in a neo-classical growth model.

To give some feel for the order of magnitude of the effects we are looking at consider how military expenditure might be introduced into a simple Solow-Swan growth model with an exogenous savings rate. Suppose output  $Y_t$  is determined through a constant returns to scale Cobb-Douglas production function by capital  $K_t$  (physical and human), labour enhancing technology  $A_t$ , and Labour,  $L_t$ ,

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \quad (1)$$

the parameter  $\alpha$  measures the share of capital in output. The capital stock is equal to gross investment,  $I_t$ , plus depreciated capital stock of the last

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<sup>2</sup>The sensitivity of the results to estimation issues and choice of sample is illustrated by the difference between the results of Attanasio et al. (2000) and Bond et al (2010) on the time-series relationship between investment and growth.

period, where  $\delta$  is the rate of depreciation:

$$K_t = I_{t-1} + (1 - \delta)K_{t-1}$$

output is devoted to consumption (public plus private), investment in physical and human capital and military expenditure:

$$Y_t = C_t + I_t + M_t. \quad (2)$$

Expressed as shares of output this is

$$1 = c + i + m.$$

Suppose technology grows at rate  $g$  and labour force at rate  $n$ , define  $y_t = Y_t/L_t$  and define  $(1 - \lambda) \simeq (1 - \alpha)(n + g + \delta)$ . Then we can derive the familiar transitional relationship determining growth in per-capita output:

$$\Delta \ln y_t = \kappa + (1 - \lambda) [\ln y_t^* - \ln y_{t-1}], \quad (3)$$

where the steady state equilibrium level of output is

$$\ln y_t^* = \frac{\alpha}{1 - \alpha} \ln(1 - c - m) - \ln(n + g + \delta) + gt, \quad (4)$$

and  $\kappa$  is a constant that depends on initial conditions. Notice that equation (3) can also be written in terms of the level of output rather than the growth rate:

$$\ln y_t = \kappa + (1 - \lambda) \ln y_t^* + \lambda \ln y_{t-1}, \quad (5)$$

and it will be more convenient to use this form below. Although it is common to distinguish theories of the level of output like (5) from theories of the growth rate like (3), formally they are indistinguishable as long as previous output is included as a determinant.<sup>3</sup> Therefore we will switch between referring to the effect of military expenditure on output and the effect on growth. Dunne et al (2015) provide a slightly different model in which the effect of military spending is through its impact on the 'technology' term  $A_t$ , but here we focus on the possible crowding out of investment.

This relationship has been widely estimated on cross country data, following Mankiw Romer Weil (1992), using investment in physical and human

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<sup>3</sup>The empirical issues in distinguishing between them are discussed in Lee Pesaran and Smith (1997).

capital as measures of  $(1 - c - m)$  with quite good empirical results. Although there are various problems with translating this approach to the time-series dimension, which we return to, it is a useful framework for thinking about the economic influences on growth. Writing the relationship in terms of  $(1 - c - m)$ , rather than the share of investment brings out the obvious point that the share of military expenditure has a negative effect on the growth rate during the transition to steady state by reducing the share of investment for a given savings rate. In the very long-run, once the transition to steady state is completed, the growth rate in per capita output is  $g$  and independent of the savings rate and the share of military expenditure in output. OECD countries may be close to steady state and Bond et al. (2010) do not find any effect of investment on growth for them, though they do for less developed countries.

This framework can be used to give an idea of the order of magnitude of the effects we are looking for. Suppose investment was initially 15% of GDP, the share of military expenditure was reduced from 5% to 4% of GDP and this was all transmitted to increased investment. Using conventional values, suppose  $\alpha = 0.5$ ,  $(n + g + \delta) = 0.08$ , so  $(1 - \lambda) = 0.04$ , then the cut in military expenditure should raise the transitional growth rate by about 0.25% per annum in the medium run. While this is not negligible, particularly when cumulated over many years, it is small relative to the other noise in the data, particularly for non-OECD countries.

In addition, within the context of this model this estimate may be an upper limit since it assumes that military expenditure does displace investment, one for one. This was the assumption made in Smith (1980), which like the Solow model assumed a closed economy, where total (public plus private) savings  $(Y - C - M)$  was equal to total investment. However, in an open-economy, total savings differs from total investment by the extent of the balance of payments deficit or surplus. Then equation (2) becomes

$$Y_t = C_t + I_t + M_t + X_t - S_t,$$

where  $X_t$  are exports and  $S_t$  imports.

The earlier sample used in Smith (1980) was dominated by the fixed exchange rate, balance of payments constrained international system, in which as the famous Feldstein-Horioka (1980) result showed, savings did tend to equal investment. However, with floating exchange rates, the removal of capital controls and globalisation, the balance of payments constraint was

removed and savings did not equal investment, Coakley et al. (1996). So increases in military expenditure that reduced savings no longer necessarily reduce investment in the way that they earlier had. In particular, the US was able to run a large balance of payments deficit, financing its investment and military expenditure from the savings of the rest of the world.

One must also recognise that, military expenditure may influence other parameters of the model, by changing the inducement to save, the rate of technical progress, the rate of utilisation of labour and capital, the effectiveness of human capital etc.<sup>4</sup> In the case of these other parameters it is less obvious what the direction of the effect will be let alone the size of the effect.

The discussion in this section suggests that the size of the likely effect of a one percent increase in the share of military expenditure is at most a reduction in the growth rate of one quarter of one percent and that this effect is quite small relative to the other noise in the data. Cross country GDP time series show the effects of numerous transitions which are large relative to the effects of military expenditure. Positive transitions, when a country starts to take-off and catch-up can raise growth rates by 5% per annum or more, 20 times the effect of a reduction in the share of military expenditure by one percent. One explanation for such transitions is that in most poor countries there are a range of institutional barriers to growth. If those barriers are removed, countries rapidly exploit their potential for catch-up and take-off. Negative transitions (wars, terms of trade shocks, financial crises or dysfunctional policies) can have equally large effects. In countries going through major negative transitions, like the former Soviet Union since 1990 the effects of even very large reductions in military expenditure can be swamped by the effects of everything else that is going on. Even in relatively stable countries like the US, it would be difficult to separate the contribution of the post Cold-War reductions in military expenditure from the contribution of all the other 'New Economy' factors to the higher productivity growth in the mid-late 1990s. Given the importance of other factors and shocks to growth, it is probably necessary to have quite sophisticated models of the process to separate the small signal we are interested in (the effect of military expenditure on growth) from the noise (everything else that is going on).

That said, the recent creation of an extended consistent military spending database by SIPRI provided by SIPRI and the large changes in military spending that occurred with the ending of the Cold War and the recent

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<sup>4</sup>Deger and Sen (1995) discuss these possible linkages within a very similar framework

growth in military spending, has provided variation in the data that did not exist for the earlier studies, providing more leverage and potentially making it easier to distinguish signal from noise in the data (Perlo-Freeman and Skons; Perlo-Freeman, 2017).

## 2.2 Economic-Security interactions

Another issue that is seldom considered in the literature is the manner in which security and economy interact to produce the military spending growth relation. For exposition, represent the economic relationship discussed above as:

$$Y_t = E(M_t, A_t) \tag{6}$$

where  $A_t$ . technology is a short hand for all the other exogenous economic determinants of output including institutions. We expect the effect of  $M_t$  on  $Y_t$  to be negative, though not large. To this economic relationship we need to add a security relationship. This can be represented by a demand for military expenditure function. This describes how the government determines its optimal military expenditure in the light of a budget constraint, represented by output, and measures of any hostile threats,  $H_t$ , from internal and external enemies, given the support it receives from allies. It can be written:

$$M_t = S(Y_t, H_t) \tag{7}$$

The effect of  $Y_t$  on  $M_t$  is positive. The size of the effect of  $H_t$  on  $M_t$  will depend on the effectiveness of military preparations in countering the particular threats a country faces. Smith (1995) reviews models of this sort, which have performed well empirically. However, in most of these optimising models output is treated as exogenous and the feedback from military expenditure to output ignored. This account assumes that military expenditures are the product of strategic perceptions and are not used as tools of economic management to stabilise the economy. The historical evidence suggests that this is a plausible assumption.

The economic and security dimensions give us two relationships between  $Y_t$  and  $M_t$ . Both growth and military expenditure are endogenous to this system, which has an equilibrium given by the intersection of the two curves:

$$\begin{aligned} Y_t &= Y(A_t, H_t) \\ M_t &= M(A_t, H_t) \end{aligned} \tag{8}$$

If  $H_t$  and  $A_t$  were independent, then the observed correlation between  $Y_t$  and  $M_t$  will be positive if the variance of  $A_t$  is large relative to the variance of  $H_t$ , and negative in the reverse case. This is exactly the same as the familiar supply-demand example of the identification problem. If there are a lot of supply shocks and no demand shocks, the movements in the supply curve will trace out the constant demand curve. If there are a lot of demand shocks and no supply shocks, the movements in the demand curve will trace out the supply curve.

For illustration consider a very simple example. Suppose we have the simultaneous system for a cross-section  $i = 1, 2, \dots, N$

$$\begin{aligned} m_i &= \beta_m g_i + \varepsilon_{mi} \\ g_i &= \beta_g m_i + \varepsilon_{gi} \end{aligned}$$

where  $m_i$  and  $g_i$  are the share of military expenditure and the growth rate. We assume  $\beta_m > 0$ , fast growing economies can spend a larger share on the military, and  $\beta_g < 0$ , military expenditure reduces growth. Define  $E(\varepsilon_{mi}^2) = \sigma_{mm}$ ,  $E(\varepsilon_{gi}^2) = \sigma_{gg}$ , and  $E(\varepsilon_{mi}\varepsilon_{gi}) = \sigma_{mg}$ . The reduced forms are

$$\begin{aligned} m_i &= [1 - \beta_g \beta_m]^{-1} (\beta_m \varepsilon_{gi} + \varepsilon_{mi}) \\ g_i &= [1 - \beta_g \beta_m]^{-1} (\beta_g \varepsilon_{mi} + \varepsilon_{gi}) \end{aligned}$$

Note that  $[1 - \beta_g \beta_m] > 0$ , since  $\beta_g \beta_m < 0$  so the sign of the regression of  $g_i$  on  $m_i$  depends on

$$\begin{aligned} Cov(gm) &= E((\beta_m \varepsilon_{gi} + \varepsilon_{mi}) (\beta_g \varepsilon_{mi} + \varepsilon_{gi})) \\ &= \beta_m \sigma_{gg} + \beta_g \sigma_{mm} + [1 + \beta_g \beta_m] \sigma_{mg}. \end{aligned}$$

Suppose  $\sigma_{mg} = 0$ , demand and supply shocks are independent, which is a common assumption, then  $Cov(gm) > 0$  if

$$\begin{aligned} \beta_m \sigma_{gg} + \beta_g \sigma_{mm} &> 0 \\ \beta_m \sigma_{gg} &> -\beta_g \sigma_{mm} \end{aligned}$$

where both terms are positive since  $\beta_g < 0$ . So the regression coefficient in a regression of growth on burden is more likely to be positive if shocks to growth,  $\sigma_{gg}$ , are large and negative if shocks to military expenditure,  $\sigma_{mm}$ , are large.



To be more specific, in the case of military expenditure if economic determinants of growth,  $A_t$ , are constant but there are variations in the threat,  $H_t$ , we will observe a negative relationship between military expenditure and output. On the other hand, if the threat is constant but the economic variables are changing we will observe a positive relationship between military expenditure and output. At a qualitative level, this simple account can be used to organise a lot of history. Consider examples of the four combinations of growth and shares of military expenditure in output.

The first case is low military expenditure and high growth. After World War II, Germany and Japan faced a relatively low threat because of US security guarantees and as a result had low shares of military expenditure. This led to higher investment which because of the growth enhancing environment they faced generated a high rate of return and high rates of growth. The growth enhancing environment was the gap with the technological leader, the US, and patterns of education and openness which allowed them to transfer the technology. As they got richer, closer to the technological leader, the potential for this sort of technology transfer was reduced and their growth rates dropped.

The second case is high military expenditure and high growth. Taiwan and South Korea faced high levels of threat, from China and North Korea respectively. It was a type of threat that military expenditure was quite effective in providing defence against, so they both spent quite a large proportion of GDP on the military. But both had a growth enhancing economic environment with high returns on investment in physical and human capital and high potential for catch-up from technology transfer which offset the depressing effect of military expenditure.

The third case is low military expenditure and low growth. The countries of Sub-Saharan Africa faced many threats, mainly internal, but they were threats against which military expenditure was relatively ineffective, so they spent relatively little on military expenditure: 1.8% of GDP compared to 2.1% in East Asia and 2.6% in South Asia (Collier and Gunning 1999). Because they had a growth inhibiting environment (wars, dysfunctional state policies, etc) they did not benefit from potential catch-up, so had low growth and low military expenditure.

The final case is high military expenditure and low growth. The Soviet Union perceived a threat against which military expenditure was seen as quite effective (challenging US hegemony and maintaining the status quo within the Warsaw Pact) so it devoted a high share of output to the mil-

itary. Added to this depressing effect, the economic environment was not growth enhancing. In particular, despite the efforts of the KGB to acquire technology, the political system inhibited technology transfer and adoption of foreign organisational practices. As a result the Soviet Union grew slowly and eventually the economic failure, to which the high military burden contributed, caused the system to collapse. While many other factors need to be added to these highly simplified accounts, these cases provide examples for all four possible combinations of growth and military expenditure.

## 3 Econometric Methods

### 3.1 Issues

For quantitative analysis of the economic effect of military expenditure on growth one needs to be able to specify the relevant economic determinants of growth (which are disputed) within a specific theoretical model and provide some measure of the exogenous threat and the effectiveness of military expenditure in countering it. In addition, the threat and military expenditure have to vary sufficiently to enable the data to trace out the economic dimension of the relationship. Quite apart from the technical details (choosing functional form, stochastic specification, appropriate proxies, etc.) this is not a straightforward agenda. If there is not enough independent exogenous variation in the data, it will be impossible to measure the effect of military expenditure on growth, even if the model is formally identified. Murdoch et al. (1997) emphasised this problem and argue that it can be avoided by pooling time-series and cross-section data for a fairly homogenous cohort of countries. They noted that pooling circumvents both the lack of variation in time-series and the problem of grouping nations with vastly different economic systems associated with large cross-section studies. This is certainly correct as long as the cross-section and the time-series variation are measuring the same parameters, but there are many cases where cross-section estimate of the relationship between two variables is quite different, e.g. opposite sign, from the time-series estimate. It is possible that the time-series relationship between military expenditure and growth is measuring the short-run effect of military expenditure on output (which is likely to be positive because of utilisation effects) while the cross-section relationship measures the long-run effect (which is likely to be negative because of investment displacement).

As another example, the general result from cross-sections is that investment has a positive effect on growth, but using panel time-series Attanasio et al. (2000) find that investment has a negative effect on growth. The pooled relationship is then a weighted average of the cross-section and time-series effects.

There is the further factor that estimation of demand for military expenditure functions, the security relationship, have been most successful in time-series. This is partly because it is difficult to get measures of the threat which are comparable across countries and can be used in cross-sections. Growth equations, the economic relationship, have been most successful in cross-section, since, in time-series it is difficult to separate the short-run demand side cyclical effects on output from the medium-term supply side growth effects.

### 3.2 Estimators

The remainder of this section reviews the estimators available for panel data. Essentially the estimators differ in how they treat parameter heterogeneity over countries and over time. Suppose we have a panel of data for countries  $j = 1, 2, \dots, N$  and years  $t = 1, 2, \dots, T$ . The simplest panel estimator is pooled OLS which just estimates a model of the form:

$$y_{jt} = \alpha + \beta x_{jt} + u_{jt}$$

on all the data. It assumes that all the parameters are the same for each country. The most common panel estimator is the (one way) fixed effect estimator, which allows the intercept to differ over countries:

$$y_{jt} = \alpha_j + \beta x_{jt} + u_{jt}.$$

This estimator only uses the within-group variation and is equivalent to the regression:

$$y_{jt} - \bar{y}_j = \beta(x_{jt} - \bar{x}_j) + u_{jt},$$

where

$$\bar{y}_j = \sum_{t=1}^T y_{jt}/T; \quad \bar{x}_j = \sum_{t=1}^T x_{jt}/T.$$

In taking deviations from group means it ignores all the information in the between-group cross-section relation:

$$\bar{y}_j = a + b\bar{x}_j + e_i.$$

Pooled OLS treats both types of information equivalently. This may not be appropriate if the cross section coefficient  $b$  measures something different from the time-series coefficient  $\beta$ . There is an estimator which is intermediate between pooled OLS and the fixed effect estimator, the random effect estimator, but we will not consider that.

One could also allow for both time and country effects to give the two way fixed effect estimator:

$$y_{jt} = \alpha_t + \alpha_j + \beta x_{jt} + u_{jt}.$$

This may capture cross-section dependence in the errors by allowing for a completely flexible trend common to all countries .

In dynamic models of the form

$$y_{jt} = \alpha_j + \beta x_{jt} + \lambda y_{j,t-1} + u_{jt}$$

the fixed effect estimator is not consistent as  $N \rightarrow \infty$ , for fixed  $T$ , because of the familiar lagged dependent variable bias because of the initial conditions. This biases the OLS estimator of  $\lambda$  downwards. However, it is consistent as  $T \rightarrow \infty$ , and for samples of our size the bias is small. If the parameters differ over groups, i.e. the true model is

$$y_{jt} = \alpha_j + \beta_j x_{jt} + \lambda_j y_{j,t-1} + e_{jt}$$

then the pooled OLS and fixed effect estimators are subject to a different, heterogeneity, bias discussed in Pesaran and Smith (1995). This arises because the error in the fixed effect equation is

$$u_{jt} = e_{jt} + (\beta_j - \beta)x_{jt} + (\lambda_j - \lambda)y_{j,t-1}$$

which will be correlated with the regressors. Unlike the lagged dependent bias this biases the estimate of  $\lambda$  upwards (in the standard case where  $x_{it}$  is positively serially correlated) towards unity. The bias in the long-run effect is smaller because the estimate of  $\beta$  is biased down and that of  $\lambda$  biased up and these two cancel out, to some extent, in estimating  $\beta/(1 - \lambda)$ . In cases where  $T$  is large, this bias can be avoided by estimating each equation individually, not imposing homogeneity, and then taking a weighted or unweighted average of the individual estimates, the Mean Group estimator (MG). A common weighted average is the Random Coefficient Model estimator suggested by Swamy (1970), which is one of a class of empirical Bayes estimators, reviews of which can be found in Hsiao, Pesaran and Tahmiscioglu (1999).

## 4 Empirical Analysis

### 4.1 Investment

The data for military spending is taken from the Stockholm International Peace Research Institute (SIPRI) extended military spending data, Perlo-Freeman and Skons (2016), Perlo-Freeman, 2017).<sup>5</sup> The Penn World Table provides the data for GDP, population, investment as a share of GDP and employment growth. .

The first step is to examine the relationship between the share of investment and the share of military expenditure in this data. The analysis in Smith (1980) used 14 countries over 1954-1973. Two countries in that sample (Austria and Switzerland) are not included in this sample and there are five additional countries: Spain, Greece, Portugal, Norway and Turkey in the OECD 17. For countries  $j = 1, 2, \dots, N$  and years  $t = 1, 2, \dots, T$  the share of investment in GDP,  $i_{jt}$  is made a function of the share of military expenditure in GDP,  $m_{jt}$ , the growth rate in GDP per capita,  $g_{jt}$ , and the growth rate in population  $p_{jt}$  .

The first form estimated is pooled OLS (POLS) on all the data:

$$i_{jt} = \alpha + \beta m_{jt} + \gamma g_{jt} + \theta p_{jt} + u_{jt}.$$

The second form estimated is a Fixed Effect Panel Estimator (FE) which allows for a different intercept for each country:

$$i_{jt} = \alpha_j + \beta m_{jt} + \gamma g_{jt} + \theta p_{jt} + u_{jt}.$$

The third form estimates a separate regression for each country

$$i_{jt} = \alpha_j + \beta_j m_{jt} + \gamma_j g_{jt} + \theta_j p_{jt} + u_{jt},$$

and then computes the Mean Group (MG) estimator of the mean of the coefficients. A cross section regression using the whole time period means is also reported.

In addition, a dynamic model with error correction form was estimated using fixed effects, pooled mean group (PMG), which allows the short run

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<sup>5</sup>Military expenditure in the SIPRI database refers to all government spending on current military forces and activities, including salaries and benefits, operational expenses, arms and equipment purchases, military construction, research and development, and central administration, command and support.

coefficients to differ across countries but with common long run coefficients and the mean group (MG), which allows all coefficients to differ.

$$\Delta i_{jt} = \alpha_{1j} + \alpha_2 \Delta m_{jt} + \alpha_3 \Delta g_{jt} + \alpha_4 \Delta p_{jt} + \rho(\beta m_{jt-1} + \gamma g_{jt-1} + \theta p_{jt-1}) + u_{jt}.$$

The model was initially estimated over three samples. The first, N=46 is all countries with data for the whole period, the second is all N=25 is all present OECD countries with data for the whole period, excluding Luxembourg which behaves strangely, the third is a group of the larger N=17 OECD countries, which is close to those covered by Smith (1980) for the period 1961-1975. The full balanced panel runs from 1960 to 2014 and two sub samples are created for the period up to the ending of the Cold War (1960-85) and the later post Cold War period, 1986-2014. This is to see whether we can replicate the earlier results on this data, which is rather different in some respects and the extent to which the results are sensitive to period and set of countries used.

Table 1 shows the estimates of  $\beta$  and their t statistic values for the different specifications and samples, with estimates in bold significant at 10% or less. Estimates of  $\gamma$  are not reported, but were always positive, though of varying significance. The first noticeable thing is the variety of results across the methods and samples. The range of these estimates and of their significance indicates the sensitivity of the results to the treatment of parameter heterogeneity in the panel. There are some features, but they are not well pronounced. The static estimates for the whole period show significant positive coefficients, particularly for the FE and no significant negative effects, but the dynamic results in particular the PMG and MG show significant negative estimates. When the results are broken down into the two periods, the earlier period now shows more negative coefficients than the later, for the static model and larger samples, but the dynamic models give larger significant negative coefficients for the dynamic specifications. Cross country averages were also estimated, but were all insignificant.

**Table 1. Estimates of  $\beta$ , the (long-run) effect of the share of military expenditure on investment), and t ratio (in parentheses) various samples.**

Whole period 1960-2014

	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
1960 – 2014						
$N = 46$	<b>0.22</b>	<b>0.32</b>	0.09	<b>0.33</b>	<b>-0.35</b>	<b>-3.14</b>
$NT = 2484$	(4.8)	(5.2)	(0.1)	(1.8)	(-2.0)	(-2.0)
$N = 25$	0.04	<b>0.46</b>	-0.32	0.15	<b>-0.61</b>	<b>-5.56</b>
	(1.0)	(8.1)	(-0.2)	(1.1)	(-2.8)	(-2.0)
$N = 17$	-0.07	<b>0.92</b>	-0.62	<b>-1.01</b>	<b>-0.94</b>	<b>-7.24</b>
	(-0.7)	(8.0)	(-0.4)	(-2.6)	(-3.6)	(-1.8)

First period: 1960-85

	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
1960 – 85						
$N = 46$	<b>0.19</b>	-0.09	-0.92	0.33	<b>-1.57</b>	<b>-2.68</b>
$NT = 1350$	(3.1)	(-0.9)	(-1.2)	(1.1)	(-4.4)	(-1.7)
$N = 25$	0.05	-0.004	<b>-2.53</b>	0.04	<b>-2.00</b>	<b>-6.34</b>
	(0.9)	(-0.1)	(-2.2)	(0.2)	(-4.4)	(-2.5)
$N = 17$	<b>-0.62</b>	<b>-0.79</b>	<b>-2.0</b>	<b>-2.15</b>	<b>-2.14</b>	<b>-7.07</b>
	(-3.9)	(-3.7)	(-1.6)	(-3.8)	(-4.8)	(-2.0)

Second period: 1986-2014

	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
1986 – 2014						
$N = 46$	<b>0.32</b>	0.17	<b>0.22</b>	<b>-0.35</b>	<b>0.33</b>	<b>-0.61</b>
$NT = 918$	(5.3)	(0.7)	(4.8)	(-2.0)	(1.9)	(-2.0)
$N = 25$	<b>0.46</b>	-0.03	0.04	<b>-0.61</b>	0.15	<b>-5.56</b>
	(8.1)	(-0.1)	(1.0)	(-2.8)	(1.1)	(-2.0)
$N = 17$	<b>0.92</b>	-0.68	-0.07	<b>-0.94</b>	<b>-1.00</b>	<b>-7.20</b>
	(8.0)	(-1.0)	(-0.7)	(-3.6)	(-2.6)	(-1.8)

Unlike the earlier period, covered in Smith (1980), there is no consistent result of a negative effect of the share of military expenditure on the share of investment. There is evidence that allowing for the short run dynamics and heterogeneous coefficients makes a negative result more likely and for the second period there is more evidence for a negative effect in the  $N=17$  group. But there is quite a large dispersion in the estimates.

The theory was based on a fixed savings ratio where military expenditure displaced investment, but national savings determines investment only in a closed economy. In an open economy, which many of these countries increasingly became over the period, investment can be financed from abroad, breaking the link to some extent. Certainly, economies have become more open to capital flows over this period and the assumption of a fixed savings ratio is also questionable. So it is not surprising that the relation becomes more complex, less well defined and affected by heterogeneity.

## 4.2 Growth

The model of growth in section 2.1 was

$$\Delta y_t = \kappa + (1 - \lambda) [y_t^* - y_{t-1}], \quad (9)$$

where the steady state equilibrium level of output is

$$y_t^* = \frac{\alpha}{1 - \alpha} \ln(1 - c - m) - \ln(n + g + \delta) + gt, \quad (10)$$

and this would suggest an approximation of the form:

$$\Delta y_{jt} = a + b \ln i_{jt} + c \ln m_{jt} + d \ln(n_{jt} + g + \delta) + e y_{jt-1} + ft$$

where  $y_{jt}$  is per-capita GDP,  $i_{jt}$  the share of investment in GDP,  $m_{jt}$  is the

share of military expenditure in GDP,  $n_{jt}$  is the rate of growth of population. For estimation  $g + \delta$  was set equal to 0.05. As an example, the one way fixed effects estimates and (t ratios) for the OECD countries N=25 were

$\alpha_i$	$\ln m_j$	$\ln i_j$	$\ln(n_{it} + g + \delta)$	$\ln y_{t-1}$	$t$	
-0.019	0.079	-0.047	-0.062	0.001		$R^2 = 0.306$
(-5.67)	(16.23)	(-4.25)	(-10.85)	(4.80)		$SEER = 0.024$

These show a well specified growth equation and a clear negative and significant effect of military burden on growth and a positive significant effect of investment. Breaking down by sample and period gave the results in Table 2. In contrast to the investment function results, the growth model results give consistently negative coefficient, though significance varies greatly. When the dynamic models are used, the coefficients are often more negative, though the dynamic MG does given some strange results, probably because



of extreme values. When Japan was dropped from the 25 country sample the whole period results for the dynamic model became significant.

**Table 2 Growth Model estimates of (long-run) coefficient of military expenditure on growth**

Results for whole period 1960-2014

1960 – 2014	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
<i>N</i> = 46	<b>-0.003</b> (-2.69)	<b>-0.014</b> (-6.08)	<b>-0.007</b> (-4.36)	<b>-0.302</b> (-3.73)	<b>-0.256</b> (-5.41)	<b>-3.841</b> (-0.70)
<i>N</i> = 25	-0.0004 (-0.36)	<b>-0.019</b> <b>-5.67</b>	<b>-0.023</b> <b>-1.96</b>	<b>-0.402</b> <b>-3.94</b>	<b>-0.118</b> <b>-2.28</b>	-2.586 -0.90
<i>N</i> = 17	<b>-0.008</b> <b>-3.47</b>	<b>-0.017</b> <b>-4.12</b>	<b>-0.027</b> <b>-1.68</b>	<b>-0.222</b> <b>-2.85</b>	<b>-0.317</b> <b>-2.28</b>	3.894 0.90

Results for 1960-85

1960 – 85	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
<i>N</i> = 46	<b>-0.004</b> <b>-2.09</b>	<b>-0.010</b> <b>-2.39</b>	<b>-0.039</b> <b>-2.73</b>	-0.057 -0.66	<b>-0.082</b> <b>-2.73</b>	<b>-0.232</b> <b>-1.77</b>
<i>N</i> = 25	-0.002 -1.32	-0.008 -1.42	<b>-0.059</b> <b>-2.69</b>	-0.035 -0.37	0.021 0.49	-0.169 -0.91
<i>N</i> = 17	<b>-0.014</b> <b>-4.33</b>	-0.003 -0.037	<b>-0.074</b> <b>-2.43</b>	0.152 1.38	0.138 1.81	<b>-0.350</b> <b>-1.65</b>

Results for 1986-2014

1986 – 2014	<i>Static</i>			<i>Dynamic</i>		
	<i>OLS</i>	<i>FE</i>	<i>MG</i>	<i>DFE</i>	<i>PMG</i>	<i>MG</i>
<i>N</i> = 46	-0.001 -0.50	<b>-0.008</b> <b>-2.00</b>	<b>-0.050</b> <b>-4.57</b>	-0.105 -1.37	<b>-0.284</b> <b>-4.89</b>	<b>-0.509</b> <b>-2.31</b>
<i>N</i> = 25	-0.003 1.58	<b>-0.023</b> <b>-4.14</b>	<b>-0.079</b> <b>-5.44</b>	<b>-0.427</b> <b>-2.91</b>	<b>-0.809</b> <b>-2.86</b>	<b>-0.857</b> <b>-2.93</b>
<i>N</i> = 17	0.001 0.26	<b>-0.028</b> <b>-3.87</b>	<b>-0.079</b> <b>-4.02</b>	-0.427 -1.45	<b>-0.809</b> <b>-2.23</b>	<b>-0.857</b> <b>-2.15</b>

Breaking down the time period into the earlier and lower groups showed the later period to generally have higher numbers of significant negative coefficients that are also larger negative. So the general conclusion from the growth model is of a consistent negative effect driven by the post 1985 data.

### 4.3 VAR

Above, we should strictly have treated military expenditure, growth and investment as jointly endogenous. We now do this, by estimating trivariate VARs following the approach of Attanasio et al. (2000). A two-way fixed effect VAR(2) takes the form

$$\begin{aligned}
 m_{jt} &= \alpha_{1,j} + \alpha_{1,t} + \sum_{p=1}^2 a_{1p} m_{j,t-p} + \sum_{p=1}^2 b_{1p} g_{j,t-p} + \sum_{p=1}^2 c_{1p} i_{j,t-p} + u_{1,jt} \\
 g_{jt} &= \alpha_{2,j} + \alpha_{2,t} + \sum_{p=1}^2 a_{2p} m_{j,t-p} + \sum_{p=1}^2 b_{2p} g_{j,t-p} + \sum_{p=1}^2 c_{2p} i_{j,t-p} + u_{2,jt} \\
 i_{jt} &= \alpha_{3,j} + \alpha_{3,t} + \sum_{p=1}^2 a_{3p} m_{j,t-p} + \sum_{p=1}^2 b_{3p} g_{j,t-p} + \sum_{p=1}^2 c_{3p} i_{j,t-p} + u_{3,jt}
 \end{aligned}$$

We report in Table 3 the persistence, and in Table 4 the long-run effects, .Given the known sensitivity of VARs to reduced numbers of observations, the estimations is only done for the full period. Table 3 shows the results for persistence, the sum of the coefficients on the lagged dependent variable, which are relatively consistent across the samples and consistent with earlier results. The military expenditure share persistence has a value of 0.92 for the whole sample and 0.93 for the large OECD country sample, Investment, the investment share, also shows high persistence and Growth, the growth of GDP) shows relatively low persistence, all coefficients were strongly significant. Estimating a first order VAR gave similar results.

**Table 3. Persistence in the VAR1 and VAR2.**

	VAR2	VAR1	VAR1	VAR2	VAR1	VAR2
	N=46		N=25		N=16	
Growth	0.302	0.245	0.366	0.311	0.325	0.247
Investment	0.815	0.817	0.786	0.787	0.812	0.821
Milex	0.918	0.921	0.933	0.931	0.885	0.897

**Table 4 Long run effects of the share of military expenditure**

	VAR2		VAR1		VAR1		VAR1	
	Growth	p-value	Invest	p-value	Growth	p-value	Invest	p-value
N=46	-0.05	0.29	0.07	0.27	-0.02	0.61	0.05	0.16
N=25	-0.01	0.20	0.21	0.20	0.01	0.86	0.04	0.29
N=16	-0.02	0.81	-0.20	0.28	-0.06	0.63	-0.42	0.67

Table 4 shows the estimated long-run effects of military expenditure, the sum of the coefficients on military spending divided by one minus the sum of the coefficients on the lagged dependent variable, for growth and the investment share. Also given is the p-value, for the hypothesis of zero coefficients on military spending: no Granger causality. The effects of military expenditure on growth are nearly all negative, but all are insignificant, -0.05 for the full sample and lower at -0.01 for the large OECD sample and -0.02 for N=16. The long-run effect of military expenditure on investment is 0.07 in the VAR(2), but is not significant and nor are any of the other coefficients. Military expenditure is not Granger-causal for either growth or investment in these VARs. As with the recent findings of Kollias and Paleogolou (2017), there is again, little evidence of a robust quantitative link between military expenditure and growth, or investment when using VAR methods.

## 5 Conclusions.

In the context of a growing literature with a lack of consensus, this paper has provided a survey of the theoretical and empirical issues involved in studying the interaction between military expenditure, investment and growth and the econometric issues in estimating the effects of military expenditure through the investment channel. A range of empirical results for a balanced panel of countries over the period 1960 to 2014, suggested that the negative relationship between military expenditure and investment noted in Smith (1980) is no longer so clearly apparent in the data. Instead the range of results depending on sample, specification and estimation method suggest, in line with the theoretical discussion, that it is somewhat difficult to estimate a precise effect of military expenditure on growth. The estimates were very sensitive to the precise way that heterogeneity in the panel was treated and one could obtain quite different estimates with different estimators. This is a common feature of the empirical growth literature and not peculiar to measuring the effect of military expenditure.

Identification is a major issue. The observed correlation between output and military expenditure is likely to be negative if the system is driven by strategic shocks and positive if it is driven by economic shocks. In order to address the identification question it is necessary to estimate a demand for military expenditure function as a simultaneous system with the output

and investment equations. Estimating the demand for military spending is not straightforward because of the difficulty of measuring strategic factors as Cavatorta & Smith (2017) discuss. Specifying a structural exogenous growth model with the share in military spending included, does seem to provide support for a negative effect, but again there are differences over time and considerable heterogeneity. This might suggest that more work needs to be done on developing a better structural model for the analysis and d'Agostino et al (2017) certainly get better results and consistent negative effects using an endogenous rather than an exogenous growth model specification.

One possibility is to consider the joint estimation of the demand and supply system. The demand for military expenditure raises some interesting issues because there is both a cross-section dimension (burden sharing) and the time-series dimension through the national budget constraint and variations in the threat. It is not clear that simultaneity bias is a major problem with the estimates presented here, since the VAR estimates suggested that military expenditure was independent of investment and growth, allowing it to be treated as exogenous. This lack of association could be the product of omitting relevant economic and strategic control variables, but it does suggest that the effects of military expenditure are rather small. There is certainly little evidence of any robust quantitative link between military expenditure and growth and so little evidence to suggest that a policy of increasing military spending would provide a useful means of increasing investment and growth.

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## **Appendix**

### **Sample N=46:**

Argentina , Australia, Austria, Belgium, Brazil, Burkina Faso, Canada, Chile, Colombia, Denmark, Dominican Republic, Ecuador, Finland, France, Germany,

Greece, Guatemala, India, Ireland, Israel, Italy, Japan, Jordan, Luxembourg, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Nigeria. Norway, Pakistan, Paraguay, Peru, Portugal, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, Venezuela (Bolivarian Republic of),

**Sample N=25 (\* N=17 sample):**

Australia \*, Austria, Belgium\*, Canada\*, Chile, Denmark\*, Finland, France\*, Germany\*, Greece\*, Ireland, Israel, Japan\* (dropped for N=16), Italy\*, Mexico, Netherlands\*, New Zealand, Norway\*, Portugal\*, Spain\*, Sweden\*, Switzerland, Turkey\*, United Kingdom\*, United States\*.