Military Expenditure Growth and Investment

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Abstract

This paper uses a panel of data 28 countries over the period 1960-1997 to examine the relationship between military expenditure, investment and growth. 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. Then it provides estimates of various models examining the interaction between the three variables. 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 involved.

1 Introduction

The effect of military expenditure on growth has been an issue of keen concern to those interested in the economics of defence, since at least Benoit (1973).

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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 does not seem to indicate any robust empirical regularity, positive or negative. Rather separately from the defence literature there also has been a revival of interest among economists in the determinants of growth, partly prompted by the availability of the Summers-Heston (1991) dataset. This vast empirical literature has also not generally found military expenditure to be an important determinant of growth, although its role has been investigated. Knight et al (1996) is a partial exception. The literature on military spending and growth is surveyed in Sandler and Hartley (1995) and by Deger and Sen (1995) and Ram (1995). The more general empirical growth literature in economics is surveyed by Temple (1999). The concern in the growth literature is the sustained medium to longer term effects (more than five to ten years) on output rather than the short term effects. More general issues on the 'peace dividend', including the short-term efffects of military expenditure on output, are surveyed in Gleditsch et al. (1996) and Chan (1995). There is also a separate literature on the economic causes and consequences of conflict, but here we shall focus on military expenditure.

One basic issue is that of identification. Because there is two-way causality between output and military expenditure, this can produce both positive and negative correlations between them. Thus interpreting the estimates raises difficulties. A second issue 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. We then have to separate these small effects from all the other factors that influence variations in the growth rate. In such circumstances our estimate of the effect is likely to be quite sensitive to the econometric methods and specification employed. This is important, because there are substantial disputes within the economics literature about the determinants of growth and investment, let alone military expenditure, and different estimators can give very different results. Section 2 uses a standard growth model to examine the economic and security dimensions of the relationship between military expenditure 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 some empirical estimates for a panel of 28 countries over the period 1960-1997. Section 5 contains some conclusions.

2 Theory

2.1 Military Expenditure in a neo-classical growth model.

There is no consensus on growth theory, but 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 Cobb-Douglas production function by capital K_t (physical and human), labour enhancing technology A_t, and Labour, L_t,

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

the parameter α measures the share of capital in output. The capital stock is equal to gross investment, I_t, plus depreciated capital stock of the last period, where δ 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:

$$Y_t = C_t + I_t + M_t.$$

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:

$$\Delta \ln y_t = \square + (1-\lambda)\left[\ln y_t^* - \ln y_{t-1}\right], \tag{2}$$

where the steady state equilibrium level of output is

$$\ln y_t^* = \frac{\alpha}{1-\alpha}\ln(1-c-m) - \ln(n+g+\delta) + gt, \tag{3}$$

and $\square$ is a constant that depends on initial conditions. Notice that equation (2) can also be written in terms of the level of output rather than the growth rate:

$$\ln y_t = \square + (1-\lambda)\ln y_t^* + \lambda \ln y_{t-1}, \tag{4}$$

and it will be more convenient to use this form in the next section. Although it is common to distinguish theories of the level of output like (4) from theories of the growth rate like (2), formally they are indistinguisable as long as previous output is included as a determinant[1]. Therefore we will switch between referring to the effect of military expenditure on output and the effect on growth.

This relationship has been widely estimated on cross country data, using investment in physical and human capital as measures of $(1-c-m)$ with quite good empirical results, see for instance Mankiw Romer Weil (1992). Although there are various problems with translating this approach to the time-series dimension, which we will 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.

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 may be an upper limit since it assumes that military expenditure does displace investment, one for one, as in Smith (1980) and the estimates discussed below suggest that this may not be the case. In addition, 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 labor and capital, the effectiveness of human capital etc. Deger and Sen (1995) discuss these possible linkages within a very similar framework. In

[1] The empirical issues in distinguishing between them are discussed in Lee Pesaran and Smith (1997).

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.

Sandler and Hartley (1995) call this investment displacement account a demand-side model and note that nearly all demand-side models, which have usually been estimated on cross-section data, have found a negative effect on growth. They distinguish these from supply-side models, particularly the Feder-Ram model, which has been widely used in the defence-growth literature, though not in the wider growth literature. The Feder-Ram model introduces separate production functions for each sector (e.g. civilian and military, though more sectors may be added) and derives a relationship for the determination of aggregate output. Typically these studies make the growth rate a function of the rate of growth of the labour force, the share of investment and the product of the growth rate and the share of military spending. Sandler and Hartley note that these models have found either a small positive defence impact on growth or no impact at all. The Feder-Ram model has generally been estimated on time-series data[2], thus there is the possibility that this nominally supply-side model is actually picking up short-run demand-side effects of military expenditure on utilisation. The utilisation effects can certainly be be important in the short-run: if the factors of production, labour and capital, are underemployed military expenditure raises output by increasing effective demand. However, in the medium to longer term it is not clear that the possible positive supply-side effects of military expenditure on human capital formation or technological change are likely to be large relative to the negative supply-side effects caused by reduced investment and capital stock, identified by the equation above.

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-

[2] Or panel data, which is discussed further below.

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 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).

2.2 Economic-Security interactions

For exposition, represent the economic relationship discussed above as:

$$Y_t = E(M_t, X_t) \tag{5}$$

where X_t are all the other exogenous economic determinants: savings, technology, lagged output, etc. and 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 recieves from allies. It can be written:

$$M_t = S(Y_t, H_t) \tag{6}$$

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:

$$\begin{aligned} Y_t &= Y(X_t, H_t) \\ M_t &= M(X_t, H_t) \end{aligned} \tag{7}$$

If H_t and X_t were independent, then the observed correlation between Y_t and M_t will be positive if the variance of X_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.

In the case of military expenditure if economic determinants of growth, X_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 openess 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 military. 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 indicate 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) emphasise 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 note 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. 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. For instance, as was suggested with respect to the Feder-Ram model above, 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. Testing for the compatibility of the time-series and cross-section dimensions is thus important. Murdoch et al. (1997) do this by using a Hausman test.

There is the further factor that 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. Growth equations, the economic relationship, have been most sucessful in cross-section, since as we have seen, 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 $j = 1, 2, ..., N$ and years $t = 1, 2, ..., T$. In this case $N = 28$ and $t = 1960 - 1997$. 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 is also known as the within estimator, because it only uses the within group variation and is equivalent to the regression:

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

where

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

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

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

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 β. 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 allows 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 $N \to \infty$, for fixed T, because of the familiar lagged dependent variable bias because of the initial conditions.

This biases the OLS estimator of λ 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 λ 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 β is biased down and that of λ 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. A common weighted average is the Random Coefficient Model (RCM) estimator suggested by Swamy (1970). It 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 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).

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. The basic equation makes the share of investment in GDP a function of the share of military expenditure in GDP and the growth rate. The first form estimated is Pooled OLS on all the data:

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

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

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

The third form estimates a separate regression for each country

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

and then computes the Swamy (1970) Random Coefficient estimator of the mean of the coefficients. The model was initially estimated over four samples. The first is using the 12 countries included in Smith (1980) using the early period 1961-1975, which is the most comparable. Then the sample of 17 OECD countries over the early period. Then the 12 country sample using the whole period 1960-1996; then the 17 countries over the whole period. 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. Estimates of γ are not reported, but were always positive, though of varying significance.

Table 1. Estimates of β (the effect of the share of military expenditure on investment) and t ratio (in parentheses) various samples.

	OLS	FE	RCM
$N=12$	-1.10	-0.56	-2.67
$early$	(-6.7)	(-2.40)	(-0.74)
$N=17$	-0.40	-0.47	-2.20
$early$	(-2.00)	(-1.80)	(-0.85)
$N=12$	-0.88	0.68	0.27
$whole$	(-8.23)	(4.4)	(0.15)
$N=17$	-0.28	0.37	0.37
$whole$	(-2.41)	(2.61)	(0.28)

The first row, which has the most comparable sample shows the same features as Smith (1980). The extreme result for the RCM, which averages the individual estimates reflects an outlier, which makes the effect large but not significant. Adding the extra countries which were generally poorer than the original sample reduces the effect of military expenditure, though it remains significantly negative in the pooled though not the fixed effect estimator. Again the effect remains in the whole sample period using the original twelve countries and OLS. But fixed effect and RCM give positive estimates of the effect of the share of military expenditure on the share of investment. Although there is still some cross-section negative relation which is being picked up by the pooled OLS estimator, the time series evidence, unlike the earlier period, is now not consistent with a negative effect of the share of military expenditure on the share of investment.

The theory was based on a fixed savings ratio where military expenditure displaced investment. National savings determines investment only in a closed economy, in an open economy investment can be financed from abroad, breaking the link to some extent. Certainly, economies have become more open to capital flows over this period. The assumption of a fixed savings ratio is also questionable. To investigate the issue further the equation making the share of investment a function of the share of military expendure and growth was estimated on the full sample of 28 countries, using five different estimators. The estimate of β (t ratio) for RCM (weighted average of the country specific coefficients) was 0.535 (0.69); between cross-section on averages: -0.33 (-1.32); Pooled OLS -0.16 (-3.12); one way fixed effects: -0.04 (-0.66); two way fixed effects: -0.17 (-2.14). The last allows a different intercept for each country and for each year, thus allowing a completely flexible trend. These year effects were very significant. The range of these estimates and of their significance indicates the sensitivity of the results to the treatment of parameter heterogeneity in the panel. The estimates of γ, not reported, are all positive.

4.2 Growth

The model of growth in section 2.1 was

$$\Delta y_t = \square + (1-\lambda)\left[y_t^* - y_{t-1}\right], \tag{8}$$

where the steady state equilibrium level of output is

$$y_t^* = \frac{\alpha}{1-\alpha}\ln(1-c-m) - \ln(n+g+\delta) + gt, \tag{9}$$

This would suggest an approximation of the form:

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

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, and lagged values of m and i were used. The one way fixed effects estimates and t ratios for N=28 were:

α_i	$\ln m_{jt-1}$	$\ln i_{jt-1}$	$\ln(n_{it}+g+\delta)$	y_{t-1}	t	
	-0.008	0.0136	-0.045	-0.035	0.001	$R^2 = 0.201$
	-2.269	2.314	-4.500	-4.95	0.467	$SER = 0.030$

The two way fixed effects estimates were

α_i	$\ln m_{jt-1}$	$\ln i_{jt-1}$	$\ln(n_{it}+g+\delta)$	y_{t-1}	α_t	
	-0.002	0.0137	-0.044	-0.028		$R^2 = 0.297$
	-0.620	2.391	-4.567	-4.07		$SER = 0.028$

The RCM estimates are

$\ln m_{jt-1}$	$\ln i_{jt-1}$	$\ln(n_{it}+g+\delta)$	y_{t-1}	t
0.003	-0.012	-0.141	-0.116	0.002
0.297	-0.640	-1.366	-3.35	1.33

There are a number of interesting features of the estimates. Firstly the heterogeneity bias in the coefficient of the lagged dependent variable, d, is very evident in the fixed effect estimators relative to the RCM. The coefficient of military expenditure is again sensitive to estimation method, being negative and significant in the one way fixed effect, negative and insignificant in the two way fixed effect and positive and insignificant in the RCM estimates. In the RCM estimates the effect of investment on growth is negative, the opposite of the standard cross-section result.

4.3 VAR

As the final investigation of the relationship, we follow the approach of Attanasio et al. (2000). They estimated a trivariate VAR between the growth rate, the investment rate and the savings rate, testing for Granger Causality. We shall use the same approach using the share of military expenditure instead of the savings rate. They found that savings Granger causes investment with a positive effect; investment Granger causes growth rates, with a negative effect; growth Granger causes investment, with a positive effect; and savings were not influenced by growth or investment. A fourth order VAR was estimated using the two way fixed effect estimator. This takes the form

$$\begin{aligned} m_{jt} &= \alpha_{1,j} + \alpha_{1,t} + \sum_{p=1}^{4} a_{1p} m_{j,t-p} + + \sum_{p=1}^{4} b_{1p} g_{j,t-p} + \sum_{p=1}^{4} c_{1p} i_{j,t-p} \\ g_{jt} &= \alpha_{2,j} + \alpha_{2,t} + \sum_{p=1}^{4} a_{2p} m_{j,t-p} + + \sum_{p=1}^{4} b_{2p} g_{j,t-p} + \sum_{p=1}^{4} c_{2p} i_{j,t-p} \\ i_{jt} &= \alpha_{3,j} + \alpha_{3,t} + \sum_{p=1}^{4} a_{3p} m_{j,t-p} + + \sum_{p=1}^{4} b_{3p} g_{j,t-p} + \sum_{p=1}^{4} c_{3p} i_{j,t-p} \end{aligned}$$

We report the persistence, the sum of the coefficients on the lagged dependent variable, and the long-run effects, the sum of the coefficients on the relevant independent variable divided by one minus the sum of the coefficients on the dependent variable. Each column represents an equation, thus the diagonal elements give the measures of persistence.

Table 2. Persistence and Long Run effects in the VAR.

	M	G	I
M	0.824	-0.005	-0.492
	(45.11)	(-0.06)	(-1.49)
G	0.134	0.270	1.51
	(1.34)	(4.39)	(4.56)
I	0.014	-0.060	0.860
	(0.300)	(-1.44)	(42.80)

Thus the first equation says that the persistence of military expenditure is 0.824 and very significant, the long-run effect of growth on military expenditure is 0.134 and not significant, and the long-run effect of investment on military expenditure is 0.014 and not significant. The share of military expenditure and the share of investment are highly persistent, the growth rate is not. The only significant long-run effect is that of growth on investment. Investment has a negative effect on growth, as in Attanasio et al. (2000) but unlike there it is not significant. In the equation for the share of military expenditure all four lags of the share are significant and no other coefficient is. In the growth equation, the third lag of the share of military expenditure is just singificantly negative (t=-2.006) with a coefficient of -0.29, the only other significant coefficient is the first lag of growth. In the investment equation, the share of military expendture with two lags is just significant (t=2.44) with a coefficient of 0.25. The RCM estimates were very similar except that the degree of persistence was lower for each of the variables as expected from the heterogeneity bias and in the case of growth, no longer significantly different from zero. The effect of investment on growth is now significantly negative. Once again we find little evidence of robust quantitative links between military expenditure and growth or investment.

5 Conclusion.

This paper provided a brief survey of the theory of the interaction between military expenditure, investment and growth; discussed the econometric issues in estimating the effects of military expenditure from panel data; and reported some tentative empirical results for a panel of 28 countries. The empirical results suggested that the negative relationship between military expenditure and investment noted in Smith (1980) is no longer apparent. The results also suggested that, in line with the theoretical discussion, it is difficult to estimate a precise effect of military expenditure on growth. In addition 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. Joint estimation of the two systems is a subject for future research. The demand for military expenditure raises some interesting issues because there is both a cross-section dimension (burden sharing among allies discussed in Sandler and Murdoch 2000) 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 ommiting relevant economic and strategic control variables, but it does suggest that the effects of military expenditure are rather small.

References

Attanasio, O.P. L. Picci and A Scorcu (2000) Saving, Growth and Investment: A macroeconomic analysis using a panel of countries, *Review of Economics and Statistics,* 82, 2, 182-212.

Benoit, Emile (1973) *Defence and Economic Growth in Developing Countries*, Boston: D.C. Heath.

Chan, Steve (1995) Grasping the Peace Dividend: Some Propositions on the Conversion of Swords into Ploughshares, *Mershom International Studies Review*, vol 39, p53-95.

Collier, Paul and Jan Willem Gunning (1999) Explaining African Economic Performance, *Journal of Economic Literature*, vol 37, p64-111.

Deger, Saadet and Somnath Sen (1995) Military Expenditure and Developing Countries, Chapter 11 of Hartley and Sandler (1995) p275-307.

Gleditsch, N.P., O Bjerkholt, A Cappelen, R P Smith and J Dunne, Editors (1996) *The Peace Dividend*, Elsevier.

Hartley, Keith and Todd Sandler, Editors (1995) *Handbook of Defence*

Economics, Amsterdam: Elsevier Science.

Hsiao, C., M.H. Pesaran and A. K. Tahmiscioglu (1999) Bayes Estimation of short-run Coefficients in Dynamic Panel Data Models, in *Analysis of Panels and Limited Dependent Variable Models: A Volume in Honour of G.S. Maddala* edited by C. Hsiao, K. Lahiri, L-F Lee and M.H. Pesaran, Cambridge: Cambridge University Press.

Knight, M, N. Loayza and D. Villanueva (1996) The Peace Dividend: Military Spending Cuts and Economic Growth, *IMF Staff Papers*, 43, 1.

Lee, Kevin, M. Hashem Pesaran and Ron Smith (1997) Growth and Convergence in a Multicountry Empirical Stochastic Solow model, *Journal of Applied Econometrics*, vol 12, 357-392.

Mankiw, N.G., D. Romer and D.N. Weil (1992) A contribution to the empirics of economic growth, *Quarterly Journal of Economics*, 107, May, 407-37.

Murdoch, James C, Chung-Ron Pi and Todd Sandler (1997) The Impact of Defense and Non-defense Public Spending on Growth in Asia and Latin America, *Defence and Peace Economics*, vol 8, p205-224.

Pesaran, M.H. and Ron Smith (1995) Estimation of long-run relations from dynamic heterogeneous panels, *Journal of Econometrics*, 68, 79-114.

Ram, Rati (1995) Defence Expenditure and Economic Growth Chapter 10 of Hartley and Sandler (1995), p251-273.

Sandler, Todd and Keith Hartley (1995) *The Economics of Defence*, Cambridge UK: Cambridge University Press.

Sandler, Todd and James C. Murdoch (2000) On Sharing NATO defence burdens in the 1990s and beyond, *Fiscal Studies*.

Smith, Ron P (1980) Military Expenditure and Investment in OECD countries 1954-73, *Journal of Comparative Economics*, vol 4, no 1, March, 19-32.

Smith, Ron P (1995) The Demand for Military Expenditure, Chapter 4 of Hartley and Sandler (1995) p69-87.

Smith, Ron P. (2000) Defence Expenditure and Economic Growth in Making Peace Pay, A Bibliography on *Armament and Conversion*, edited by Nils Petter Gleditsch et al, Regina Books Claremont Ca.

Summers R and A Heston (1991) The Penn World Table (Mark V); an expanded set of international comparisons 1950-1988, *Quarterly Journal of Economics*, 106, 327-68.

Swamy, P.A.V.B. (1970) Efficient Inference in a Random Coefficient Regression Model, *Econometrica* 38, 311-323.

Temple, Jonathan (1999) The New Growth Evidence, *Journal of Economic Literature*, vol 37, 1, p112-156.