Military Expenditure, Endogeneity and Economic Growth

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Abstract

The debate over the economic effects of military spending continues to develop, with no consensus, but a deepening understanding of the issues and limitations of previous work. One particularly important issue that has not been adequately dealt with, is the possible endogeneity of military spending in the growth equation, mainly because of the difficulty of finding any variables that would make adequate instruments. This paper considers the likely importance of endogeneity, using conflict onset as an instrument for military spending in an endogenous growth model for a panel of African countries 1989-2010. The empirical analysis suggests that endogeneity is likely to be an important issue and using IV estimation provides a larger significant negative effect for military spending on growth than OLS. This suggests earlier studies have underestimated the damaging effects of military spending.

Keywords: Military expenditure; economic growth; development; instrumental variables

JEL Classification: C26; H56; N17; O11

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1. Introduction

The effects of military spending on the economy continues to be a subject of considerable debate, with a lack of consensus in the literature (Dunne and Uye, 2009). Research has led to an improved understanding of the processes by which military spending may influence growth, but has also shown the complexity of trying to tease out the economic processes at work. As more post Cold War data becomes available, the advantage of a more complex strategic environment and more movement in the data should be making the identification of any long run relationships more apparent and this does seem to be the case. Once the estimation period is not dominated by the specifics of the Cold War, the results seem to be more consistent in finding a negative relation between military spending and growth (Dunne and Tian, 2013).

There is, of course, considerable heterogeneity and while results are being shown to be relatively robust, there is still considerable work to be done. Much of the recent cross country work has used panel data and has taken advantage of the growing experience of dynamic panel data models to good effect. Most recent studies start with an underlying theoretical model, some form of endogenous or exogenous growth model, with military spending or burden included as an explanatory variable, providing a possible theoretical justification for this adopted growth model, but the addition of military spending is often done in a relatively ad hoc manner (Dunne *et al.*, 2005). Generally, once an empirical model has been specified, it is estimated as a single equation growth model, which tends to side step an important issue of potential endogeneity. Military spending may be affected by growth and the literature on the demand for military spending suggests to analyse its relevance (Dunne *et al.*, 2008). On the other hand, it is in principle possible that estimates reflect unmeasured shifts in the military spending and almost certainly correlated with higher risk of a lower growth. One reason for the lack of consideration of this issue is that it is very difficult to think of useful instruments for military spending. This raises similar issues to those in the debate over the impact of aid on growth in developing countries, summarised in Deaton (2010).

This paper considers the likely importance of endogeneity, using an endogenous growth model for a panel of Sub Saharan African (SSA) countries 1989-2010. This allows a more precise identification of the effect of military spending on growth than the previous literature. The next section provides a brief review of the literature on the effects of military expenditure on growth. Section 3 then presents the the theoretical model, with Section 4 analysing the empirical models, discussing identification issues and justifying the use of the proposed instrument, namely conflict onset, for the panel of SSA countries and Section 5 describing the data and providing some empirical justification for the chosen instrument. This is followed by estimation results in Section 6, with Section 7 providing some analysis of the robustness of the results. Finally some conclusions are presented in Section 8.

2. Military Expenditure and Growth

Developing a theoretical model is important for any empirical study, but much of economic theory does not have an explicit role for military spending as a distinctive economic activity. This has not prevented the development of theoretical analyses, however, as discussed in Dunne and Coulomb (2008). In empirical work the fact that there is no agreed theory of growth among economists means that there is no standard framework that military spending can be fitted into. Clearly, in developing countries military spending, conflict, economic capacity (education, governance, institutions, natural resources) all interact to influence growth. Indeed, many poor countries, even those with civil wars, spend relatively little on the military. In particular many African countries have low military burdens, but suffer from other obstacles to growth (Collier, 2007). Theoretical work has allowed the identification of a number of channels through which military spending can impact on the economy, in the short run through potential substitution effects with other government components, and in long run through labour, capital, technology, external relations, socio-political effects, debt, conflicts etc.. The relative importance and sign of these effects and the overall impact on growth can only be ascertained by empirical analysis (Smith, 1989).

An important issue in empirical work is the identification problem that results from the fact that changes in military spending and growth are observed but both are influenced by security threats. If the economic determinants of growth are constant, but there are increases in the security threat - which are positively correlated with military spending - a negative relationship between military expenditure and output will be observed (Aizenman and Glick, 2006). On the other hand, if the threat decreases, a positive relationship between military expenditure and output will be observed, without the other variables changing. This can be used to explain some country experiences with different combinations of growth and military expenditure. It also suggests caution in interpreting the results of empirical studies (Smith, 2000).

Clearly all of the channels mentioned will interact and their influence will vary depending on the countries involved. For example, a relatively advanced developing country will have concerns over the industrial impact of their involvement in arms production, the technology and foreign direct investment benefits versus the opportunity cost, while a poorer African economy may be more concerned with the conflict trap they find themselves in Collier (2007).

Debate in the empirical literature on the economic effects of military spending started with the contribution of Benoit (1973, 1978), which purported to show that military expenditure and development went hand in hand. This led to considerable research activity using econometric analysis to overcome the deficiencies, most of which has tended not to support Benoit, but there is still no consensus view (Dunne and Uye, 2009). Surveys of the military spending-growth literature include Chan (1987), who found a lack of consistency in the results, Ram (1995) who reviewed 29 studies, concluding that there was little evidence of a positive effect of defence outlays on growth, but that it was also difficult to say the evidence supported a negative effect. Dunne (1996) covering 54 studies concluded that military spending had at best no effect on growth and was likely to have a negative effect, certainly that there was no evidence of positive effects and (Smith, 2000) observed that the large literature did not indicate any robust empirical regularity, positive or negative, though he felt there was a small negative effect in the long run, but one that requires considerably more sophistication to find. Smaldone (2006) in his review of Africa considered military spending relationships to be heterogeneous, elusive and complex, but argued that variations could be explained by intervening variables, with negative effects tending to be wider and deeper in countries experiencing legitimacy/security crisis and economic/budgetary constraints. Dunne and Uye (2009) in a survey of 102 studies on the economic effects of military spending in developing countries found only around 20% found a positive effect and that models allowing for a demand side, and hence the possibility of crowding out investment, tended to find negative effects, unless there is some reallocation to other forms of government spending. Those with only a supply side found positive, or positive but insignificant, effects, something that is not surprising, given such models are inherently structured to find such as result (Brauer 2002; d'Agostino *et al.* 2012a,b summarise the debate). More recently, Dunne and Tian (2013) survey of almost 170 studies and suggests that the availability of increasing post cold war data, with its higher signal to noise ratio, is leading to more consistent results than in the past and moving the literature towards a consensus finding, that military spending has a negative impact on economic growth. But concerns remain, particularly over issues of identification and endogeneity which, while often discussed in the determinants of conflict literature, are seldom considered in the milex-growth literature, aside from the use of GMM methods that instrument with predetermined variables for military spending. This is mainly due to the lack of obvious candidate variable that could be used as instruments. This paper considers the importance and effects of endogeneity on growth, but first the theoretical model employed in the analysis is presented.

3. The baseline growth model

Using the endogenous growth model of Barro (1990) as a starting point, the framework is extended to allow for two different categories of government spending. Thus, the economy consists of a representative household and government, with the household producing a single composite commodity, which can be consumed, accumulated as capital, or paid as income tax. It derives utility $[U(c)]$ from consumption c, maximising the discounted sum of future utilities $u(c)$, expressed in logarithmic form. Total output per capita $[y]$ is produced with a constant returns to scale technology, which uses the private capital stock k, and the two different forms of government spending, g_1 and g_2. If the functional form is Cobb Douglas, the resultant private capital accumulation function is: $[\dot{k} = (1-\tau)y-c]$, where τ is the is a flat-rate income tax[1]. The government is assumed to collect income tax revenue τ to finance total public spending g, between the components g_1 and g_2, with ϕ_1 and ϕ_2 denoting the share of resources devoted to each component. Under this government budget constraint and the assumption that the tax rate τ is constant, the steady state growth equation can be expressed in terms of shares of resources

[1]Since the focus is on the composition of expenditure, issues of financing of government expenditures are ignored. This means that there is no deficit financing in the model as the government is constrained to run a balanced budget, and that the role of the structure of taxes is not analysed in examining the effect of total government spending on per-capita growth (Devarajan *et al.*, 1996).

devoted to each component ϕ_1 and ϕ_2 as[2]:

$$\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}\left(\phi_1\right)^{\frac{\alpha}{1-\alpha-\beta}}\left(\phi_2\right)^{\frac{\beta}{1-\alpha-\beta}} - \rho \tag{1}$$

where ρ is the rate of time preference, A is the exogenous technology and α and β are the relative productivity parameters of g_1 and g_2, respectively.

To investigate the properties of the model the optimal levels of the different components of government expenditure, $\phi_i = [\phi_1, \phi_2]$ are derived. Under the condition:

$$\sum_{i=1}^{2}\phi_i = 1 \quad \Longrightarrow \quad \phi_1 = 1-\phi_2, \tag{2}$$

the effect of the component ϕ_1 on the growth rate is characterised by the relationhip with the other share of government spending. That is, if the financing rule (2) is always binding, the effect of the components of government spending depends on the relative share ϕ_i and output elasticities. Combining (1) with (2) to give $\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}\left(\phi_1\right)^{\frac{\alpha}{1-\alpha-\beta}}\left(1-\phi_1\right)^{\frac{\beta}{1-\alpha-\beta}} - \rho$, gives the partial derivative of γ with respect to ϕ_1:

$$\frac{\partial\gamma}{\partial\phi_1} = \left\{\left[\frac{\alpha}{\phi_1} - \frac{\beta}{\phi_2}\right]\lambda\right\} \tag{3}$$

where $\lambda = (1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}\left(\phi_1\right)^{\frac{\alpha}{1-\alpha-\beta}}\left(1-\phi_1\right)^{\frac{\beta}{1-\alpha-\beta}} > 0$, and the sign of the partial derivative depends on the parameters in the squared parentheses of the equation.

For example, to investigate whether the government spending component g_1 is productive, the partial differential of output with respect to ϕ_1 requires that:

$$\frac{\partial\gamma}{\partial\phi_1} \geq 0 \quad if \quad \frac{\phi_1}{\phi_2} \leq \frac{\alpha}{\beta},$$

while the component of government spending will be classified unproductive if:

$$\frac{\partial\gamma}{\partial\phi_1} < 0 \quad if \quad \frac{\phi_1}{\phi_2} > \frac{\alpha}{\beta}.$$

This formulation allows the impact of an exogenous shock that changes one component of government spending to be analysed, taking into account whether this effect will lead

[2]For an extensive description of the model, see d'Agostino *et al.* (2012b).

to an increase or a decrease in economic growth rate.

4. The empirical model

As section 2 argued, estimating the effect of military spending on the growth rate of GDP is not a trivial task and for this reason the variety of empirical results obtained in the empirical work should not be surprising. Much of the literature has focused on estimating cross-country regressions and has dealt with a range of issues. There has, however, been little concern for the possibility that the estimated relationships could have problems of omitted variables, with unobserved variables affecting economic growth and military spending simultaneously and so biasing the estimation results, or reverse causation resulting, for example, from economic growth increasing the resources available for government spending and so increasing military spending. A related issue arises from the theoretical endogenous growth model in section 3. When the government budget constraint is given, a shock that increases military spending may also reduce other forms of government spending, such as education, health, or general government spending, which might also have an effect on growth. So it would seem sensible to extend the empirical model to allow for controlling the potential contemporaneous reallocation of resources across the different components of government spending on growth.

Focusing upon the military component of government spending, the cross country relation between military spending ($Military_i$) and economic growth (γ_i) has generally been specified as a reduced form equation:

$$\gamma_i = \beta_0 + \beta_1 Military_{it} + \beta_2 X_{it} + \beta_3 S_i + \epsilon_i \tag{4}$$

where X_i is a vector of control variables, which includes non military spending to control for government spending re-allocation, and the initial level of private investments as a proxy for the country-technology. In addition, Equation in (1) implies that the growth rate will also depends on the initial capital stock or GDP per capita (in logs), thus initial GDP per capita is included in the vector X to control for conditional convergence. Finally, we include country fixed effects S_i to account for differences between countries that the vector X_i does not controlled.

There still remain possible identification problems. As argued before, military spending may be influenced by feedback effects, as increased growth may lead to increased military spending, or expectations of the outcome of the process undertaken by the state to allocate expenditures allocation, may be correlated with the current growth rate. Thus, military expenditure cannot simply be assumed to be exogenous, so the empirical estimates are not easy to interpret because there are potentially other factors at play. To deal with this, an instrumental variable (IV) approach can be used, but the problem is identifying suitable instruments. In fact, it is not clear what would make a good instrument, a problem that is not restricted to this issue, as the debate over growth and aid summarised in Deaton (2010) shows.

One candidate is the onset of civil conflict in a country. At first sight this might not seem a sensible instrument, given its possible relation with growth, but it is likely to act as a shock on military spending but not necessarily on growth. It certainly seems worthwhile investigating its suitability empirically as the literature has suggested a path from economic growth to the onset of conflict (see Miguel *et al.* 2004; Miguel and Satyanath 2010, 2011), but Ciccone (2013) using the data of Miguel *et al.* (2004) found that civil conflict onset did not seem to be driven by per capita growth income shocks. It also appears from the data that military spending increases with the onset of the conflict, as measured by the PRIO fatalities threshold of 25 deaths, but that the damaging effects of conflict on the economy start before this threshold. In this way conflict onset may well be a good candidate as an instrument for military spending.

Formally, specifying the growth and military spending reduced forms as:

$$Military_{it} = \theta_0 + \theta_1 Civil\ conflict_{it} + \theta_2 X_{it} + \theta_3 S_i + \theta_4 T_t + v_{it} \quad (5)$$

$$\gamma_{it} = \delta_0 + \delta_1 Civil\ conflict_{it} + \delta_2 X_{it} + \delta_3 S_i + \delta_4 T_t + u_{it} \quad (6)$$

in which T_t accounts for time-varying unobserved effects, with X_{it} and S_i as defined above. The causal effects of military spending on growth can be obtained by estimating:

$$\gamma_{it} = \Phi_0 + \Phi_1 Military_{it} + \Phi_2 X_{it} + \Phi_3 S_i + \Phi_4 T_t + d_{it} \quad (7)$$

where the covariate-adjusted IV estimate of the coefficient on military spending (7) is the ratio of the reduced form coefficients on military spending, that is $\Phi_1 = \delta_1/\theta_1$. Note that, IV estimator in the just identified case is strictly an indirect least square estimator (ILS)[3]. The existence of a clear and significant discontinuity in both military spending and growth from a shock related to civil conflict onset would suggest that it can be used to identify and estimate the impact of military spending on growth (Hahn *et al.*, 2001; Oreopoulos, 2006). This issue is considered empirically in a next section.

5. Data and econometric issues

To estimate the model, data was collected for sub-Saharan African countries for the period 1989 to 2010. The onset of the civil conflict ($Civil\ conflict\_it$) was constructed using the International Peace Research Institute of Oslo, Norway (PRIO), and University of Uppsala binary conflict onset variable, which takes the value 1 if the conflict has exceeded 25 (i.e., minor conflicts) battle-related deaths, and 0 if it has not [4]. The growth rate of per-worker GDP (γ_{it}) and the log value of GDP per-capita ($Ln(GDP\ per\ capita)_t$) were taken from the World Bank's World Development Indicators (WDI). Military spending, as percentage of GDP ($Military_{it}$), was taken from the Stockholm International Peace Research Institute (SIPRI) database (SIPRI Yearbook, 2012). Civilian public spending as a share of GDP ($Nonmilitary_{it}$) was computed by subtracting military spending in GDP from the government consumption share of PPP adjusted GDP per capita at current prices. A variable measuring private investments as share of PPP adjusted GDP per capita at current prices ($Private - investment$), taken from the Penn World Table 7.0, is also used. Appendix A reports the variables and their sources and presents some descriptive statistics.

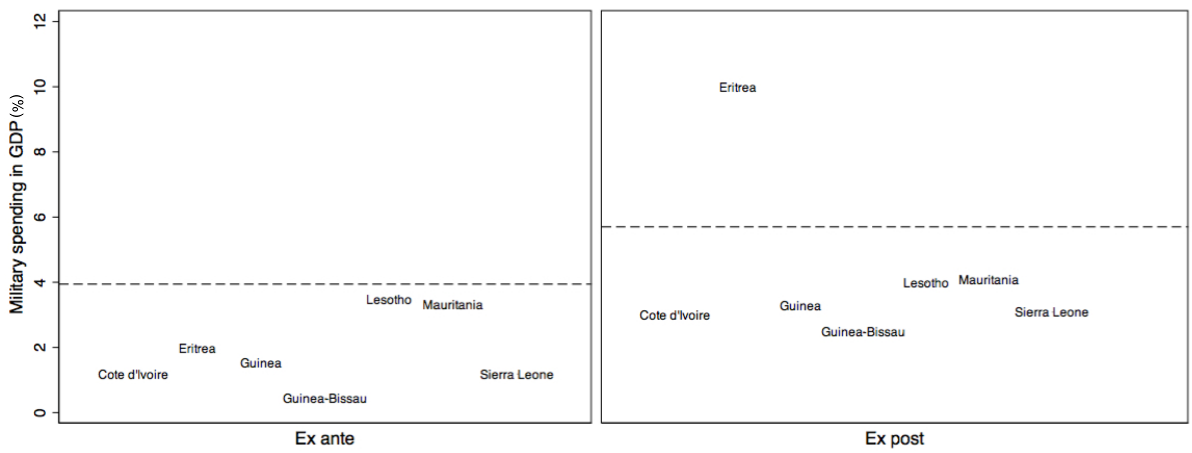
As discussed in section 4, the IV approach proposed, using conflict onset as an instrument for military spending, requires empirical justification, but to be certain that conflict acts as an exogenous shock to the countries, it is first necessary to exclude any countries that have non-consecutive periods of civil conflict (i.e. multiple conflicts over time) along with countries those that were already involved in conflict in the year the data series start. Appendix B lists the countries involved in the treatment group, the one in the control group and the excluded countries. Next, it is necessary to show that conflict

[3]For mathematical derivation and discussion, see Angrist and Pischke (2009, pg. 121).

[4]A civil conflict is defined in the PRIO/Uppsala database as a contested incompatibility, which concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state (Blattman and Miguel, 2010).

onset has the properties required of an instrument. To get some idea of the impact of conflict onset Figure 1 shows the share of military spending in GDP for countries affected by conflict, before and after the year in which the conflict started. The horizontal line in Figure 1 shows the change in the cross-country mean of the variable and shows a clear and marked increase of the proportion of military spending in GDP for each country after the onset of conflict. Figure 2 does the same for growth and shows that countries affected by conflict have lower growth immediately after the start of the conflict, implying a negative correlation between conflict and growth. As Figure 3 shows this result is confirmed when the forward lag growth outcome is used, though the magnitude of the difference is on average small.

Figure 1: *Cross-country mean of military spending before and after the civil conflict onset*



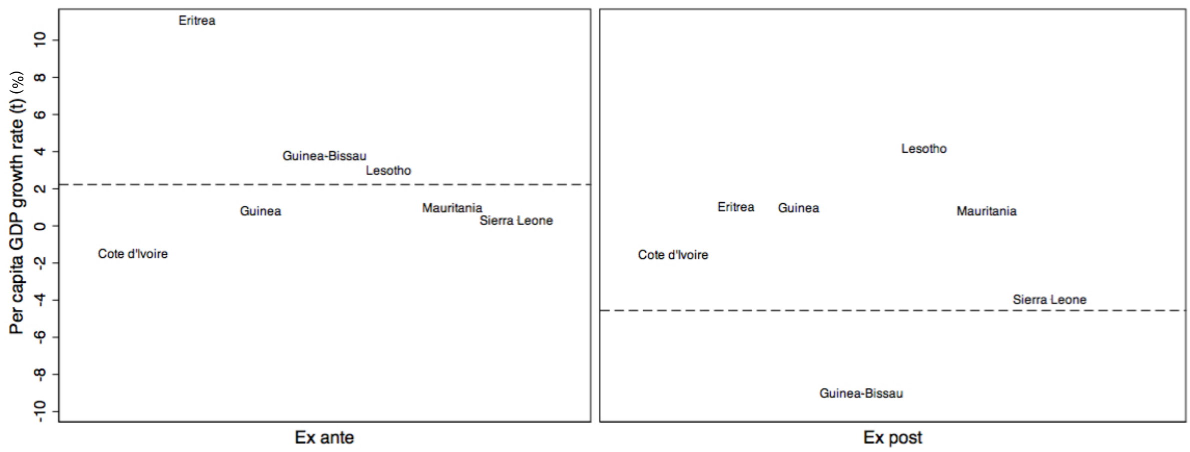
Notes: This graph shows countries affected by the onset of conflict in the period, defined as a civil conflict in progress with at least 25 battle deaths per year. The left hand panel shows the country mean of military burden in the year before the civil conflict and the right hand panel the same for the year after the onset of conflict. The mean does not include Eritrea because in the year before the conflict (1996) it had a military burden of 20.03 per cent and 32.5 per cent in 1997. The values for Eritrea are scaled down by a proportion of 5 to assist in the visualisation.

The econometric question is whether conflict onset is a valid instrument in this situation. This means asking first, whether it significantly explains part of the variation in military spending and, second, checking that it is not correlated with the unobserved factors in both the growth rate and military spending equations[5]. To test the first issue, the reduced form military spending equation (5) is estimated to see if conflict onset is a strong predictor for military spending. Following Miguel *et al.* (2004) a "false experiment" is used to evaluate identification, by extending the reduced form (equation 5) to include

[5]The same arguments can be used for the other variable considered in the empirical specifications, civil conflict intensity.

the conflict onset variable at time $t+1$, which should be orthogonal to current military spending. Prior to that it is possible to provide a descriptive analysis, by presenting the results of a nonparametric local regression of civil conflict onset on military spending graphically using the Epanechnikov kernel method. Figure 4 shows a positive and approximately linear relationship between the instrument and the endogenous variable, suggesting it is not a weak instrument by this criteria Bound *et al.* (1995).

Figure 2: *Cross-country mean of growth rate before and after the civil conflict onset*



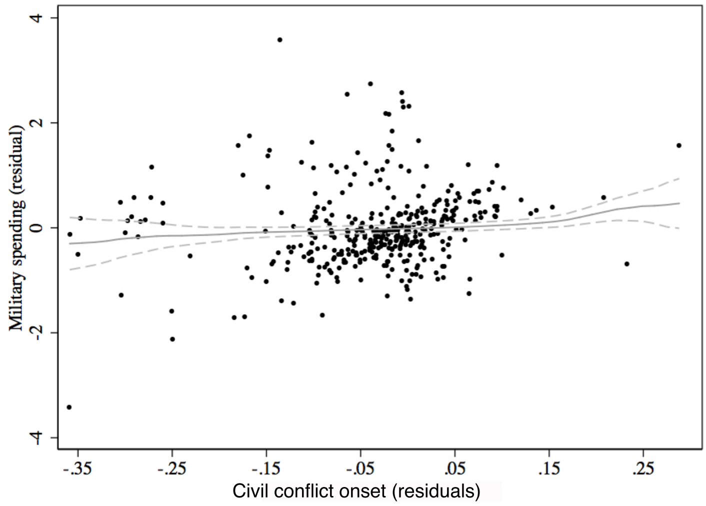
Notes: This graph uses the sample of countries were affected by the onset of conflict, defined as a civil conflict in progress with at least 25 battle deaths per year. On the left is the country mean of the growth rate in the year before the civil conflict, while on the right is the mean for the same variable after the onset of conflict.

Figure 3: *Cross-country mean of growth rate before and after the civil conflict onset*

Notes: This graph uses the sample of countries that were affected by the onset of conflict, defined as a civil conflict in progress with at least 25 battle deaths per year. On the left is the country mean of the growth rate in the year before the civil conflict, while on the right is the mean for the same variable after the onset of conflict.

Note that the variation induced by the civil conflict is "local" in nature, in the sense that countries change their military spending in response to this exogenous shock. Imbens and Angrist (1994); Angrist (1995); Angrist *et al.* (1996) show that under certain conditions, with heterogeneous treatment effects the IV method identifies the Local Average Treatment Effect (LATE), that is the average effect of a treatment on those countries whose treatment status is changed by the instrument (Kluve *et al.*, 2013).

Figure 4: *Current military spending and civil conflict onset/intensity, conditional on time fixed effects and control variables.*



Notes: This graph plots military spending and civil conflict onset/intensity residuals. The continuous line is the local polynomial smoothed line, whereas the dashed lines are the 95% confidence intervals. Civil conflict onset/intensity residuals are obtained using a non parametric estimation procedure conditional on time fixed effects and control variables. Military burden residuals are obtained by a linear regression model, conditional on time fixed effects and control variables.

Another problem that plagues most analyses is the possibility that the instrument may not satisfy the exclusion restriction. In this case, unobserved determinants may affect the causal estimation of the relationship between military spending and growth. For example, if military spending is found to be negatively associated with growth, it need not necessarily mean that it is unproductive in the usual macroeconomic sense as slow-growing countries could spend more on the military to reduce internal threats and then later allocate more to productive government spending to increase growth. The internal threats (e.g., omitted variable) may be linked with the onset of conflict and impact on military spending and the economy. Thus, to obtain "causal" estimate of this relationship verification is needed that the intrument used is not correlated with unobservables that are correlated with military spending and growth. In this framework, conflict onset is a variable that affects military spending that can legitimately be omitted from equation (4) or (7) if estimated by OLS[6]. Potential endogeneity caused by reverse causality is returned to later.

6. Results

Estimating equations 5, 6 and 7, gave the results in Tables 1,2 and 3. Table 1 show the results for the first stage correlations (equations 5), with civil conflict onset having a significant positive effect on military spending, at over 99 percent significance level (regression 1, column 1a: $\theta_1 = 1.342$), and this relationship is robust to the inclusion of country-specific controls (regression 2: $\theta_1 = 0.863; p - value = 0.065$). Standard errors in all the tables are clustered by World Bank income group classification (Garcia and Moore, 2012), to allow for intragroup correlation.

Table 1: *Civil conflict onset and military spending (Equation 5) - Dependent variable: military spending in GDP*

	Specifications		
Explanatory Variables	(1)	(2)	(3)
$Civil\ conflict_{it}$	1.342	0.863	1.621
	(0.390)	(0.231)	(0.785)
	[0.075]	[0.065]	[0.175]
$Civil\ conflict_{it+1}$			-1.505
			(1.252)
			[0.352]
Time fixed effect	yes	yes	yes
Country fixed effects	yes	yes	yes
Covariate country effect	no	yes	yes
Number of observations	477	416	416
Log-Likelihood	-758.979	-660.754	-655.184
R^2	0.884	0.890	0.893

Notes: Standard errors are listed in round parenthesis, while *p-value* are reported in square brackets. The standard errors are clustered by World Bank income group classification (Garcia and Moore, 2012).

Including civil conflict onset at time $t+1$ constructs the false experiment discussed in Section 5, giving a variable that is orthogonal to the military spending at time t ($\theta_t + 1 = -1.505; s.e. = 1.252$) and providing, along with the results of Figure 4, further support for the use of conflict onset as an instrument. Equation 5 was also estimated

[6]See, for a similar discussion Machin et al., (2011).

Table 2: *Civil conflict onset and per capita GDP growth (Equation 5) - Dependent variable: per capita GDP growth*

	Specifications	
Explanatory Variables	(1)	(2)
$Civil\ conflict_{it}$	-6.486	-4.307
	(2.225)	(1.249)
	[0.100]	[0.075]
$Non\ military_{it-1}$		0.197
		(0.025)
		[0.016]
$ln(GDP\ per-capita)_{it-1}$		-15.911
		(2.907)
		[0.032]
$Private-investment_{it-1}$		0.078
		(0.106)
		[0.540]
Time fixed effect	yes	yes
Country fixed effect	no	yes
Number of observations	477	416
Log-Likelihood	-1328.546	-1133.573
R^2	0.252	0.371

Notes: Standard errors are listed in round parenthesis, while *p-value* are reported in square brackets. The standard errors are clustered by income group classification of World Bank (Garcia and Moore, 2012).

using an alternative instrument, civil conflict intensity, giving a smaller coefficient than for conflict onset and, interestingly, a significance level below at the minimum of the confidence interval (e.g., 90% significance level)[7]. This suggests that the two indicators of conflict are likely to be having different effects, with conflict onset picking up conflicts quickly and the intensity variable, with its higher battle death requirement, only kicking in after the conflict has been going on for a while. This could mean that by the time the intensity variable picks up the existence of a ”major conflict” it is less likely to have an exogenous shock or lead to unexpected reactions in terms of expenditures on the military sector by policy-makers.

Estimating the reduced form growth equation (e.g., equation 6) gave the results in Table 2, which show conflict onset and intensity to have negative and significant coefficient estimates for the two specifications. The results in column (1) gave a point estimate of -4.3 ($s.e. = 1.249$), when country control variables are included, and is statistically

[7]The estimates are not reported here to save space, but are available on request.

significant between 90 and 95 percent significance level. This is the preferred specification discussed below, as some control variables are statistically significant at least at the 90 percent significance level. Interestingly, these estimates suggest that the onset of civil conflict causes a reduction in the per-capita GDP growth rate that is somewhat larger that 2.2% per annum reduction in growth rate that Collier (1999) estimated for civil wars and that has been generally supported by more recent studies (Dunne, 2012). Note that finding a positive and significant correlation between non military expenditure and the growth of per capita GDP in the civil conflict-growth reduced form equation, is consistent with earlier findings in the literature (d'Agostino *et al.*, 2012b,a), and indicates that excluding non military spending from estimated growth equations is likely to mean upward biased estimates, because of the positive relation between the errors and the growth rate.

The results in Table 3 for the IV estimator of equation (7), assuming conflict onset is a valid instrument, show military burden to significantly and negatively affect per-capita GDP growth. As mentioned earlier, the reduced-form estimates can provide a check for the IV method as the structural parameter estimate for the coefficient on military burden is given by $\Phi_i = \delta_i/\theta_i$. The point estimate for conflict onset is $\Phi_1 = -4.989$ $(p - value = 0.005)$, which is equal to the ratio of the reduced form parameters in equation 1 and 2 respectively (i.e., $-4.307/0.86 = -4.98$). The relatively low standard error on Φ_1 provides some support for the use of the instrument, along with the partial R^2 or Shea test (Shea, 1997) reported in the Table[8]. Its value of about 0.12 which shows that the conflict onset variable accounts for a significant amount of the correlation with respect to the endogenous variable and supports its use as an instrument.

For comparison, column 2 of Table 3 presents the least squares regression results for equation (4). The coefficients estimates have the expected signs, but are considerably smaller in magnitude than the IV estimates and have a threshold of significance slightly above the 5% level in both of the models. The coefficient estimate for military burden in model (1) is -0.653 $(p - value = 0.057)$ when country-control variables are added, suggesting that endogeneity may be important. As argued above, the OLS regression is undoubtedly affected by unobservable factors that produce upward bias; for example

[8]In this case, the model contains only military spending as an endogenous variable; but, when there is more than one exogenous variable the Shea statistic corresponds to the statistic known as partial R^2 of Bound, Jaeger and Baker (1995).

Table 3: *Military spending and per-capita GDP growth rate (IV estimates; instrument: Civil conflict onset) - Dependent variable: per-capita GDP growth*

	IV	OLS	
Explanatory Variables	[eq(7)]	[eq(4)]	[eq(4)+instruments]
$Military_{it}$	-4.989	-0.653	-0.604
	(1.779)	(0.163)	(0.172)
	[0.005]	[0.057]	[0.073]
$Non\ military_{it-1}$	-0.325	0.180	-3.785
	(0.495)	(0.061)	(0.076)
	[0.511]	[0.097]	[0.220]
$ln(GDP\ per-capita)_{it-1}$	-16.032	-17.401	-15.926
	(2.012)	(3.831)	(2.308)
	[0.000]	[0.045]	[0.020]
$Private-investment_{it-1}$	0.043	0.076	0.074
	(0.018)	(0.096)	(0.098)
	[0.018]	[0.512]	[0.532]
Time fixed effect	yes	yes	yes
Country fixed effect	yes	yes	yes
$\boldsymbol{Civil\ conflict_{it}}$			-3.785
			(1.357)
			[0.108]
Number of observations	416	416	416
Log-Likelihood	-1358.072	-1130.333	-1125.600
R^2		0.380	0.394
$R^2 Shea$	0.120		

Notes: The standard errors are clustered by World Bank income group classifications(Garcia and Moore, 2012) and are in round parentheses, with *P-value* reported in square brackets. IV estimates are obtained from Equation 7, whereas OLS estimates from Equation 4. At the bottom of the IV columns is Partial-R^2 Shea (1997), which acts as a measure of instrument relevance.

countries involved in a conflict are more likely to adopt similar institutional behaviours, such as lobbying, rent-seeking etc., that could have a positive impact on military spending. This would imply that, in the growth equation, military spending and the error term are positively correlated and so the OLS estimate will underestimate the causal effect of military spending. This is an important finding as it suggests that dealing with endogeneity tends to increase the size and significance of the negative impact of military burden, which might explain why in the past many studies of developing countries have found a negative, but insignificant effect (Dunne and Uye, 2009).

In using conflict onset as an instrument, it is clear that it does explain part of the increase in military spending, but it has not yet been established that it is not correlated with the unobserved determinants that are correlated with both military burden and growth rate. An indirect but plausible quantification of endogeneity bias can be computed by including civil conflict onset in equation (4), which is the OLS specification with military spending as an explanatory variable and see if it can legitimately (statistically) be omitted from (4). This would suggest that it is not correlated with the errors. The results in column 3 of table 3 show that the estimated coefficient of civil conflict onset is not significant at the 90 percent signficant level ($p - value = 0.11$), but the coefficient for military burden remains significant within the confidence interval between 90 and 95 percent ($p - value = 0.075$) and close to the OLS estimation of equation (4) (e.g., -0.60 instead of 0.65). This provides further support for the use of conflict onset as an instrument.

7. Alternative specifications, sensitivity of samples and robustness

There are a number of potentially important issues that may limit the reliability and robustness of the results. First, it is possible that the results might be being driven by short run fluctuations. Second, it is possible that there are non linear relations that are not being picked up. In particular as identified in the literature, military spending may have different impacts at different levels of 'threat'. Finally, it is possible that endogeneity and causality may still remain despite the steps taken, reducing the reliability of the estimates. This section considers these issues and the robustness of the results.

Previous work on conflict has recognised the possibility of results being driven by short run fluctuations and starting from Collier and Hoeffler (2006) researchers have used five year averages to eliminate them. To consider this issue, and in the interests of maintaining the number of time series observations in the data, a moving average method was used on the data and the model was estimated by IV, giving the results in Table 4 (column 1). These results are consistent with those for the annual data in showing a negative and statistically significant effect of military spending on growth, with a unit increase in the ratio of military spending to total expenditure decreasing the growth rate by about 1.5 percentage points. That this is lower than for the annual data is expected, as military spending fluctuations in the short term are also drivers of institutional and economic changes that can alleviate the negative response of γ_t.

Even though the onset of civil conflict is a "good instrument", there remains concern that reverse causality may still be important. One way of testing for this is to see if specifying the dependent variable as a forward lag influences the estimates. Modelling military expenditure in period t as affecting growth in the forward lag period $t+1$ (e.g., γ_{t+1}), or in the five-year average growth rate (e.g., $\gamma_{t+1,t+5}$), from period $t+1$ through $t+5$, and interpreting any significant differences with the benchmark estimates of the model in equation (7), or its forward specifications, as evidence of the existence of potential endogeneity. Table 4 (column 2 and 3) presents these estimates and the results support the main findings, with the estimated coefficient for the forward lag military spending variable negative and significant and, while smaller, close to the benchmark estimates of the Table 3. These results suggest that the empirical estimates in Section 6 can be reported with confidence.

Table 4: *Military spending and five years average and forwarded per-capita GDP growth rate (IV estimates; instrument: Civil conflict onset)*

Explanatory variables	Five years average	Forward lag specifications	
	γ_t, γ_{t+4}	γ_{t+1}	$\gamma_{t+1,t+5}$
$Military_{it}$	-1.496	-5.241	-1.187
	(0.143)	(0.688)	(0.431)
	[0.000]	[0.000]	[0.006]
Country-specific variables	yes	yes	yes
Time fixed effect	yes	yes	yes
Country fixed effect	yes	yes	yes
Number of observations	300	395	271
Log-Likelihood	-619.571	-1339.322	-505.914
R^2	0.271	-1.522	0.414

Notes: The clusterised standard errors are listed in round parentheses, while *p-value* are reported in square brackets.

Finally, the potential impact of external threat remains as issue. High threat levels could lead countries to maintain persistently higher levels of military spending and in these countries military spending might influence growth in a different way than in countries with low threat levels (Aizenman and Glick, 2006; Pieroni, 2009). One means of testing for such effects is to compare the full sample results with a sample that excludes countries with the highest share of military spending and those that did not experience civil conflict onset, i.e., Botswana, Namibia, Seychelles, and Togo. This excludes countries that most likely to be threatening, or threatened by neighbours and with a high probability of conflict onset and those that are likely to face low threat levels and have experienced no conflict. The results in Table 5 using both annual and five-year average data, show the results to be relatively robust to the exclusions, with coefficients remaining negative and significant and close to those of the benchmark models.

Table 5: *Low military spending sub-samble and per-capita GDP growth rate (IV estimates; instrument: Civil conflict onset)*

Explanatory variables	Specifications			
	γ_t	γ_{t+1}	$\gamma_{t,t+4}$	$\gamma_{t+1,t+5}$
$Military_{it}$	-7.255	-6.979	-1.817	-2.126
	(2.814)	(0.192)	(0.031)	(0.217)
	[0.010]	[0.000]	[0.000]	[0.000]
Country-specific variables	yes	yes	yes	yes
Time fixed effect	yes	yes	yes	yes
Country fixed effect	yes	yes	yes	yes
Number of observations	316	298	225	203
Log-Likelihood	-1141.227	-1090.661	-505.205	-472.336
R^2	-2.596	-3.290	-0.023	-0.459

Notes: The clusterised standard errors are listed in round parentheses, while *p-value* are reported in square brackets. Low miltary spending sub-sample excludes Botswana, Namibia, Seychelles, Zambia, Togo, South Africa.

8. Conclusions

Debate over the economic effects of military spending continues to develop, with no consensus, but a deepening understanding of the issues and limitations of previous work. One important issue, that has not been adequately dealt with is the possible endogeneity bias in the relationship between military spending and growth equation. This paper has provided a novel approach to dealing with this issue. By implementing a growth model that allows for the effects of different components of military spending, we have developed an estimation strategy that deals with the potential endogeneity of military spending, using conflict onset as an instrument for military spending. The use of conflict onset was justified for a panel dataset of Sub Saharan African countries 1989-2010 and the endogenous growth models estimated. This entailed estimating reduced form equations, for growth and military spending, with civil conflict onset introduced as an exogenous shock. The structural IV estimate for growth is then the ratio of the reduced form coefficients and corresponds to the causal estimates of the parameters associated with military spending. As part of the procedure the impact of civil conflict was estimated, suggesting that conflict causes a reduction of nearly 4% point in the per-capita GDP growth rate in the sample, which is somewhat larger that 2.2% per annum reduction in growth rate that (Collier, 1999) estimated for civil wars and that has been generally supported by more recent studies (Dunne, 2012).

The results suggested that endogeneity was an important issue for the growth and military spending relationship. Using IV estimation, gave a larger significant negative effect for military spending on growth (-4.98) than would be given by an OLS estimator (-0.65) and these estimates were robust to alternative specification or nonlinearities. These results imply that the damaging effects of military spending on growth in Africa are being significantly underestimated in most studies.

While it is clear that conflict onset is a suitable and successful instrument in this analysis, the results are not directly generalisable. The SSA group contains a number of countries that have experienced civil conflict and are relatively poor countries and the use of conflict onset as an instrument required the exclusion of countries that had more than one conflict over the period. So conflict onset is unlikely to be applicable to a larger and more diverse panel of countries. What is of general concern is the finding that endogeneity is important and is likely to be influencing the results of studies of military spending and growth. It is important that future research tries to deal with endogeneity and the search for reasonable instruments is one that needs to engage researchers.

Appendix A: Descriptive statistics and data-source

Variable name	Source	Observations	Mean	Standard deviation
		A. Civil war measures		
$Civil\ conflict\ (onset)_{it}$	PRIO Uppsala	1031	0.214	0.411
		B. Main economic variables		
γ	WPT	876	0.672	9.727
$Military_{it}$	SIPRI	797	2.480	3.091
Non military$_{it}$	WPT-SIPRI	764	10.381	8.742
		C. Country-specific variables		
$GDP\ per-capita$	WDI	601	3713.441	5085.6
$Private\ investment$	WDI	606	24.26428	13.80077

Notes: Descriptive statistics refer to the years 1998-2010, for the full set of analysed countries. Data on civil conflict are extracted by the PRIO Uppsala dataset, military spending in GDP is extracted by the Stockholm Institute of Peace research (SIPRI). From the World Penn Table 7.0 and the World Bank's World Development Indicators (WDI) are collected all the remaining variables.

Appendix B: Civil conflict onset in Sub-Saharan Africa

Country	Civil conflict
Treatment status	
Cote d'Ivoire	onset 2001 (2004)
Eritrea	onset 1997 (1999)
Guinea	onset 2000 (2001)
Guinea-Bissau	onset 1998 (1999)
Lesotho	onset 1998
Mauritania	onset 2010
Sierra Leone	onset 1991 (2000)
Control group	
Botswana	never involved
Burkina Faso	never involved
Benin	never involved
Cameroon	never involved
Cape Verde	never involved
Equatorial Guinea	never involved
Gabon	never involved
Gambia	never involved
Ghana	never involved
Kenya	never involved
Madagascar	never involved
Malawi	never involved
Mauritius	never involved
Namibia	never involved
Sao Tome and Principe	never involved
Seychelles	never involved
South Africa	never involved
Swaziland	never involved
Tanzania	never involved
Togo	never involved
Zambia	never involved
Zimbabwe	never involved
Excluded countries	
Angola	multi-treatment onset
Central African Republic	multi-treatment onset
Chad	multi-treatment onset
Comoros	multi-treatment onset
Congo	multi-treatment onset
Djbouti	multi-treatment onset
Ethiopia	multi-treatment onset
Liberia	multi-treatment onset
Mali	multi-treatment onset
Mozanqique	multi-treatment onset
Niger	multi-treatment onset
Nigeria	multi-treatment onset
Rwanda	multi-treatment onset
Senegal	multi-treatment onset
Somalia	multi-treatment onset
Sudan	multi-treatment onset
Uganda	multi-treatment onset
Zaire	multi-treatment onset

Notes: In round parenthesis we report the ended date of each onset civil conflict.

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