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 literature on the economic effects of military spending continues to be the subject of considerable debate, though with a lack of any 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 in general the addition of military spending is done in a relatively ad hoc manner (Dunne *et al.*, 2005).

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 that it is (Dunne *et al.*, 2008). 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. 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 discussing the empirical models, discussing identification issues and justifying the use of the proposed instrument, namely conflict onset, for the panel of SSA countries. Then, Section 5 describes the data and provides some empirical justification for the chosen instrument. This is followed by estimation results in Section 6, which show that using IV estimation provides a larger significant negative effect for military spending on growth than OLS. It also identifies a further potential bias in the same direction in studies not including non-military spending in the growth equation. These results imply that the damaging effects of military spending on growth in Africa are being underestimated in most studies. Section 7 provides some analysis of the robustness of the results, checking to see if the bias found could be explained by short term fluctuations, considering possible non linearities produced by threat and using subsamples and forward lags to consider the appropriateness of the instrumental variable. The results are found to be robust. 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. However, this has not prevented the development of theoretical analyses 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 there are 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. (Dunne and Tian, 2013). The relative importance and sign of these effects and the overall impact on growth can only be ascertained by empirical analysis.

An important issue in empirical work is the identification problem that results from the fact that we observe military spending and growth changing and 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. 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).

The 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 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 find only around 20% have a positive effect and that models allowing for a demand side, and hence the possibility of crowding out investment, tend to find negative effects, unless there is some reallocation to other forms of government spending. Those with only a supply side find positive, or positive but insignificant, effects, something that is not surprising, given such models are inherently structured to find such as result (d'Agostino *et al.* 2012c,b; Dunne 2012 summarise the debate). More recently, Dunne and Tian (2013) survey 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, 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 endogenous growth model

Consider an economy consisting of representative household and government. The household produces a single composite commodity, which can be consumed, accumulated as capital or paid as income tax. It derives utility from consumption c by maximising the discounted sum of future utilities:

$$U(c) = \int_0^\infty e^{-\rho t} u(c) dt, \quad where \quad u(c) = ln(c) \tag{1}$$

where ρ is the rate of time preference and where the functional form of the instantaneous utility function $u(c)$ is expressed in a logarithmic form. Total output per capita y is produced with a constant returns to scale technology, which uses the private capital stock k, and two different forms of government spending, denoted g_1 and g_2. If the functional form is Cobb Douglas, then the relationship can be expressed as:

$$y = Ak^{1-\alpha-\beta} g_1^\alpha g_2^\beta, \quad 0 < \alpha, \beta < 1, \tag{2}$$

where A is the exogenous technology and α and β are the relative productivity parameters of g_1 and g_2, respectively. The resultant private capital accumulation function is:

$$\dot{k} = (1-\tau)y - c \tag{3}$$

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 (Devarajan *et al.*, 1996) and ϕ_1 and ϕ_2 denote the share of resources devoted to each component. The government budget constraint is then:

$$g = \tau y = g_1 + g_2 \tag{4}$$

$$g_1 = \phi_1 \tau y \tag{5}$$

$$g_2 = \phi_2 \tau y \tag{6}$$

Taking the government's decisions and τ as given[2], the representative household choses the optimal amount of private consumption so as to maximise (1) subject to the private (3), public (4), (5), (6) and the initial level of private capital k. The steady state growth equation is:

$$\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A\,(g_1)^{\alpha}\,(g_2)^{\beta}\left(\frac{g}{k}\right)^{\alpha+\beta} - \rho. \tag{7}$$

Then, by assuming that along the steady state growth path the tax rate τ is constant (which means that also g/k is constant), we can manipulate (7) by using (2), (4), (5), (6) to specify the steady state growth equation in terms of shares of resources devoted to each component ϕ_1 and ϕ_2[3]. Hence the steady state growth equation becomes:

$$\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}\,(\phi_1)^{\frac{\alpha}{1-\alpha-\beta}}\,(\phi_2)^{\frac{\beta}{1-\alpha-\beta}} - \rho \tag{8}$$

[1]Since our focus is on the composition of expenditure, we abstract from issues of financing of government expenditures. 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).

[2]While we do not analyse the government's decision problem choosing expenditure or the tax rate, we are implicitly assuming that the government chooses the tax rate τ. Since the government is constrained to run a balanced budget in the model, this effectively means that the level of government expenditure g is determined by default.

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

Here, we investigate the properties of the model by deriving the optimal levels of the different components of government expenditure, $\phi_i = [\phi_1, \phi_2]$. By assuming that the rules of financing 4, 5, 6 hold, from equation 4, we use the following condition:

$$\sum_{i=1}^{2} \phi_i = 1 \quad \Longrightarrow \quad \phi_1 = 1 - \phi_2, \tag{9}$$

in which 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 (9) is always binding, the effect of the components of government spending depends on the relative share ϕ_i and output elasticities. Indeed, by combining (8) with (9) to give $\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}(\phi_1)^{\frac{\alpha}{1-\alpha-\beta}}(1-\phi_1)^{\frac{\beta}{1-\alpha-\beta}} - \rho$, we find that the partial derivative of γ with respect to ϕ_1 is:

$$\frac{\partial \gamma}{\partial \phi_1} = \left\{ \left[\frac{\alpha}{\phi_1} - \frac{\beta}{\phi_2} \right] \lambda \right\} \tag{10}$$

where $\lambda = (1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}(\phi_1)^{\frac{\alpha}{1-\alpha-\beta}}(1-\phi_1)^{\frac{\beta}{1-\alpha-\beta}} > 0$, 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 model 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 to an increase or a decrease in economic growth rate. In this paper, the exogenous shocks on government spending are episodes of armed conflict involving a country, at a given time t, and government spending is divided into military and civil components.

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 from economic growth increasing the resources available for government spending and so increasing military spending. A related issue arises from the theoretical endogeneous 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 in which $Non\ military$ is included to control for contemporaneous government spending re-allocation :

$$\gamma_i = \beta_0 + \beta_1 Military_{it} + \beta_2 Non\ military_{it} + \beta_3 X_{it} + \beta_4 S_i + \epsilon_i \tag{11}$$

where X_i is a vector of control variables and S_i individual country effects. This specification would ignore useful information from the time variation in the data and to overcome this much recent empirical work has applied this form of model to panel data.

There still remains a possible identification problem. 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. What is needed is a variable that has a zero covariance between itself and the errors in the growth equation and a non zero covariance between itself and military spending. 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 armed 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 and whether it has a zero covariance with the growth equation errors can be tested empirically. It certainly seems worthwhile investigating its suitability empirically as the literature has generally suggested a causal path from economic growth to the onset of conflict (see Collier and Hoeffler 2004; Miguel *et al.* 2004). It would also appear that military spending increases with the onset of the conflict, as measured by the PRIO fatalities threshold of 25 deaths, but the damaging effects of conflict on the economy could start before or after that. In this way conflict onset is a good candidate as an IV for military spending.

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

$$\gamma_{it} = \delta_0 + \delta_1 Armed\ conflict_{it} + \delta_2 Non\ military_{it} + \delta_3 X_{it} + \delta_4 S_i + \delta_5 T_t + u_{it} \quad (12)$$

$$Military_{it} = \theta_0 + \theta_1 Armed\ conflict_{it} + \theta_2 Non\ military_{it} + \theta_3 X_{it} + \theta_4 S_i + \theta_5 T_t + v_{it} \quad (13)$$

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:

$$\gamma_{it} = \Phi_0 + \Phi_1 Military_{it} + \Phi_2 Non\ military_{it} + \Phi_3 X_{it} + \Phi_4 S_i + \Phi_5 T_t + d_{it} \quad (14)$$

where the IV estimate of the coefficient on military spending (14) is the ratio of the reduced form coefficients on military spending, that is $\Phi_1 = \delta_1/\theta_1$. The existence of a clear and significant discontinuity in both military spending and growth from a shock related to armed 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, with two armed conflict variables constructed using the battle-related deaths per year: conflict onset ($Armed\ conflict\ (onset)_{it}$) and conflict intensity ($Armed\ conflict\ (intensity)_{it}$). These are binary variables that take the value 1 if the conflict has exceeded 25 (i.e., minor conflicts) or 1000 (i.e., major conflict) battle-related deaths, and 0 if it has not. This data was taken from the International Peace Research Institute of Oslo, Norway (PRIO), and University of Uppsala[4] and has the advantage of recording both of these variables (Blattman and Miguel, 2010). 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 Penn World Table 7.0. and are chain indices, measured in 2005 U.S. dollars. 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 describing the trade openness of a country (*open*), measured by the sum of imports and exports as a percentage of GDP, was taken from the Penn World Table 7.0. The World Bank's World Development Indicators (WDI) provided figures for arable land as percentage of land area (*araland*), and a religious fractionalisation index ($frac$) was taken from Fearon and Latin (2003). Finally, the WDI provided data on net official development assistance and official aid received (*aid*) at constant 2008 US dollars[5]. Appendix A reports the variables and their sources and presents some descriptive statistics.

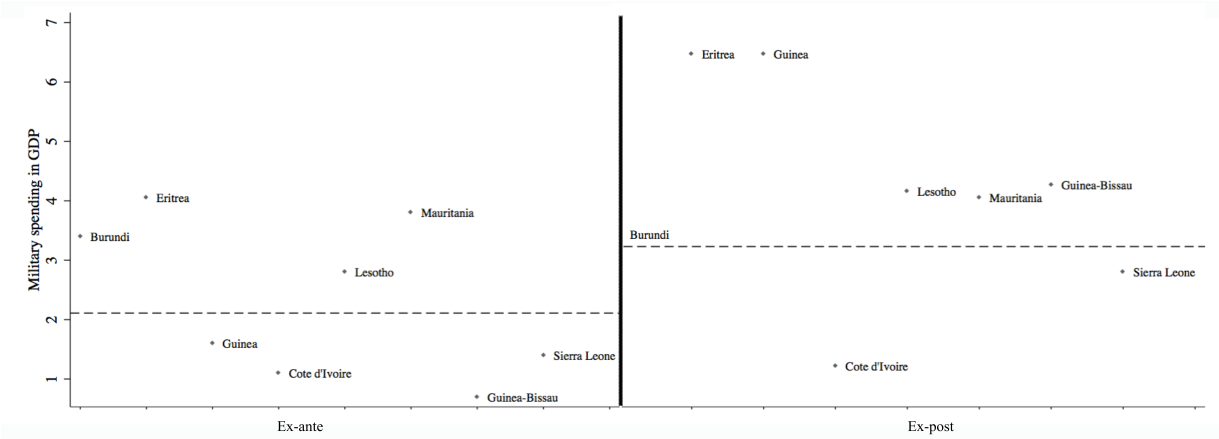
As discussed in section 4, the IV approach proposed, using conflict as an instrument for military spending, requires empirical justification, but to be certain that conflict acts

[4] An armed 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.

[5] Net official development assistance consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients (World-Bank, several year).

as an exogenous shock to the countries, it is first necessary to exclude any countries that have non-consecutive periods of armed conflict (i.e., multiple conflicts over time) along with countries those that were already involved in conflict in the year the data series start. Next, it is necessary to show that conflict 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. There is 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.

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



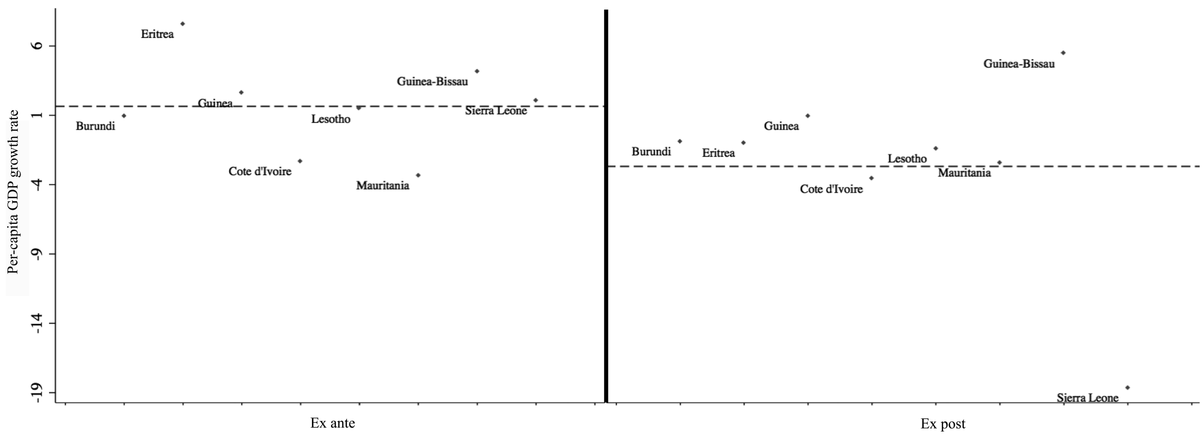
Notes: This graph shows countries affected by the onset of conflict in the period, defined as an armed conflict in progress with at least 25 battle deaths per year. The left hand panel shows the country mean of military burden in the year before the armed conflict and the right hand panel the same for 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[6]. 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. To test the first issue, the reduced form military spending equation (12) is estimated to see if conflict onset is

[6]The same argumentation can be used for armed conflict intensity, the other variable which use in the estimations.

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 13) to include 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 armed conflict onset on military spending graphically using the Epanechnikov kernel method. The left panel of Figure 3 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). The right hand panel of Figure 3 shows the results for conflict intensity and while it still indicates a positive relationship, there seems to be some evidence of nonlinearity which weakens the case for using this variable as an instrument for military spending.

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

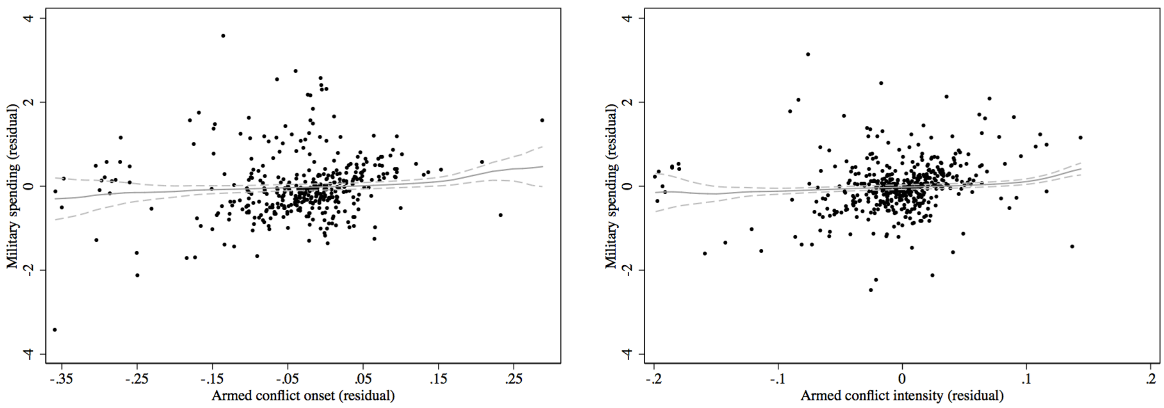


Notes: This graph uses the sample of countries that during these years were affected by the onset of conflict defined as an armed conflict in progress with at least 25 battle deaths per year. On the left, it is reported the country mean of the growth rate in the year before the armed conflict, whereas on the right the mean for the same variable after the onset of conflict.

Note that the variation induced by the armed 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. If monoticity is assumed this interpetation can be used to explain the role of conflict onset as an instrument.

As regards estimation, there is another problem to solve, that plagues most analyses of the link between categories of government expenditure and growth. It is possible

Figure 3: *Current military spending and armed conflict onset/intensity, conditional on time fixed effects and control variables.*



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

that there is joint endogeneity between categories of government expenditure and reverse causality between military spending and growth. So if military and non military spending are considered expected growth might allow increases in both or, rather than a trade off. This would suggest that 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 (e.g., Barro 1990). As an example, slow-growing countries could be affected by intermediate variables, such as political instability, spend more on the military to reduce internal threats and then later allocate more to productive government spending to increase growth. This issue is returned to later and potential endogeneity is tested for.

6. Results

Estimating equations 12, 13 and 14, gave the results in Tables 1, 2 and 3. Columns (1)-(2) of Table 1 show the results for the first stage (equations 12 and 13), with conflict onset having a significant positive effect on military spending, at over 99 percent significance level, using time fixed effects (regression 1, column 1a: $\theta_1 = 1.649$), and this relationship is robust to the inclusion of country controls (regression 2, column 2a: $\theta_1 = 1.476; s.e. = 0.349$)[7] .

[7]Note that, while such country-specific characteristics are generally difficult to measure completely, those described in Section 4 are proven to influence per-capita growth (Miguel *et al.*, 2004).

Table 1: *Armed conflict onset, armed conflict intensity and military spending (Equation 13) - Dependent variable: military spending*

	Specifications					
Explanatory variables	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
$Armed\ conflict\ (onset)_{it}$	1.649 [0.337] (0.000)		1.476 [0.367] (0.006)		1.617 [0.483] (0.000)	
$Armed\ conflict\ (onset)_{it+1}$					-0.201 (0.650) [0.442]	
$Armed\ conflict\ (intensity)_{it}$		0.568 [0.338] (0.094)		0.289 [0.348] (0.408)		0.116 [0.495] (0.814)
$Armed\ conflict\ (intensity)_{it+1}$						0.240 [0.483] (0.620)
Non military$_{it}$	-0.005 [0.013] (0.725)	-0.075 [0.014] (0.000)	-0.042 [0.019] (0.032)	-0.121 [0.017] (0.000)	-0.042 [0.019] (0.032)	-0.121 [0.017] (0.000)
Time fixed effect	yes	yes	yes	yes	yes	yes
Country-specific variables	no	no	yes	yes	yes	yes
Number of observations	474	580	412	514	412	514
Log-likelihood	-810.967	-900.439	-713.622	-798.534	-712.271	-797.291
R^2	0.849	0.872	0.861	0.885	0.860	0.885

Notes: Standard errors are in square brackets, while *p-value* are reported in round parenthesis. The vector of the control variables are listed in Appendix A and described in the footnote of the same table.

Including armed conflict onset at time $t + 1$, gives a coefficient estimate that is small and not significant ($\theta_1' = -0.201; s.e. = 0.650$) providing, along with the results of Figure 3, further support for the use of conflict onset as an instrument. When the armed conflict intensity variable is used, the results are as expected (column b, Table 1), but the coefficient estimate is smaller than for conflict onset and, interestingly, the significance level is only at the minimum of the confidence interval (e.g., 90% significance level) in column (1b) of Table 1. This suggests that the two indicators of conflict are likely to be having different effects, with the 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.

Non military spending has significant coefficient estimates in the regression when time fixed effects and country variables are controlled for (column 2 in Table 1). The estimate of a negative coefficient ($\theta_2 = -0.042; s.e. = 0.019$) is evidence of contemporaneous substitutions within government spending and, more importantly, when significant, its inclusion reduces potential upward bias of the estimated coefficients[8].

Table 2: *Armed conflict onset, armed conflict intensity and per-capita GDP growth rate (Equation 12) - Dependent variable: per-capita GDP growth*

	Specifications			
Explanatory Variables	(1a)	(1b)	(2a)	(2b)
$Armed\ conflict\ (onset)_{it}$	-5.108 [1.064] (0.000)		-4.097 [1.090] (0.000)	
$Armed\ conflict\ (intensity)_{it}$		-2.592 [1.224] (0.035)		-1.753 [1.226] (0.154)
Non military$_{it}$	0.092 [0.043] (0.033)	0.039 [0.053] (0.462)	0.138 [0.057] (0.018)	0.061 [0.061] (0.324)
Time fixed effect	yes	yes	yes	yes
Country-specific variables	no	no	yes	yes
Number of observations	474	604	412	514
Log-likelihood	-1356.794	-1707.029	-1163.353	-1444.977
R^2	0.151	0.133	0.221	0.178

Notes: Standard errors are in square brackets, while *p-value* are reported in round parenthesis. The vector of the control variables are listed in Appendix A and described in the footnote of the same table.

Estimating the reduced form growth equation (e.g., equation 12) gave the results in Table 2, which show conflict onset and intensity to have negative and significant coefficient estimates for all the specifications. The results in column (1), using the onset of conflict, gave a point estimate of -5.108 ($s.e. = 1.034$), which declines in absolute terms to around -4.1 ($s.e. = 1.090$) when country control variables are included. This is the preferred specification discussed below, as the vector of control variables (i.e., net official development assistance and official aid received, trade openness, percentage of arable land area, and religious fractionalization) are statistically significant at the 95 percent significance level. Interestingly, these estimates suggest that the onset of 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).

[8]The coefficient θ_1 estimated without including the non military variable in the specification of column 2a is 1.406.

When conflict intensity is used the coefficient estimates are lower than the onset coefficients by more than 2 percentage points and the inclusion of country-control variables affects their significance (e.g., column 2 of the specification 2, in Table 3). Finding a positive and significant correlation between non military expenditure and the growth of per capita GDP in the reduced form equation using armed conflict onset (Equation 12), 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[9].

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

	Specifications			
Explanatory Variables	(1)		(2)	
	IV	OLS	IV	OLS
$Military_{it}$	-3.098	-0.232	-2.776	-0.169
	[0.893]	[0.148]	[1.001]	[0.150]
	(0.001)	(0.118)	(0.006)	(0.264)
Non military$_{it}$	0.078	0.125	0.021	0.175
	[0.060]	[0.043]	[0.096]	[0.058]
	(0.202)	(0.004)	(0.827)	(0.003)
Time fixed effect	yes	yes	yes	yes
Country-specific variables	no	no	yes	yes
Partial-R^2	0.158		0.144	
Number of observations	475	474	414	412

Notes: Standard errors are in square brackets, while *p-value* are reported in round parenthesis. The vector of the control variables are listed in Table 1 and described in the footnote of the same table. IV estimates are obtained from Equation 14, whereas OLS estimates from Equation 11. At the bottom of the IV columns are listed Partial-R^2 Shea (1997) which measures of instrument relevance.

The results in Table 3 for the IV estimator of equation (14), 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 $\Phi_1 = -3.098$ ($p-value = 0.004$), which is equal to the ratio of the reduced form parameters in equation 2 and 1 respectively (i.e., $-5.108/1.648 = -3.098$). As expected, the IV estimates are

[9]This coefficient moves from -4.097 in our best specification to -5.349 when non military spending is excluded from the Equation 12.

not very different when the model includes country-control variables (i.e., $\Phi_1 = -2.776$ ($p-value = 0.006$)). The relatively low standard error on Φ_1 provides some support for the use of the instrument and the partial R^2 or Shea test (Shea, 1997) is also reported in the Table[10]. Its value of about 0.15 shows that the conflict onset variable accounts for a significant amount of the correlation with respect to the endogenous variable, suggesting it is relevant as an instrument, with conflict intensity having a slightly smaller value.

For comparison, Table 3 presents the least squares regression results for equation (11). 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 10% level in both of the models. The coefficient estimate for military burden in model (1) is -0.232 ($p-value = 0.148$) and -0.169 ($p-value = 0.150$) when country-control variables are added, suggesting that endogeneity may be important and may be biasing the estimated parameters. As argued above, OLS regression is undoubtedly affected by unobservable factors that produce upward bias; for example 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).

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

[10] In this case, the model contains only military spending as an endogenous variable, but more than one exogenous variable and corresponds to the statistic known as partial R^2 by Bound, Jaeger and Baker (1995). That is, it equals the squared correlation between the share of the military spending and the fit of the relevant endogenous variable orthogonal to the vector of the exogenous variables.

and causality may still remain despite the steps taken, reducing the reliability of the estimates. This section now 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 (2004) researchers have used five year averages to eliminate them $\gamma_{t,\ t+4}$. 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 preferred model was estimated by IV, giving the results in Table 4.

Table 4: *Military spending and per-capita GDP growth rate (IV estimates; instrument: Armed conflict onset) - Dependent variable: five-year average growth* ($\gamma_{t,\ t+4}$)

	Specifications	
Explanatory variables	(1)	(2)
$Military_{it}$	-2.163 [0.577] (0.000)	-1.931 [0.630] (0.002)
Non military$_{it}$	0.046 [0.042] (0.284)	-0.015 [0.062] (0.802)
Time fixed effect	yes	yes
Country-specific variables	no	yes
Number of observations	412	372

Notes: Standard errors are in square brackets, while *p-value* are reported in parenthesis. The vector of the control variables are listed in Appendix A and described in the footnote of the same table.

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 2 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 indirectly amplify the negative response of γ_t. As further support for these findings, semi-elasticity estimates for military spending are presented in Table 5, which give similar estimates.

Considering the potential impact of external threat, which could lead countries to maintain persistently higher levels of military spending and countries with high levels of threat might see military spending influence growth differently that countries with low

Table 5: *Estimates of semi-elasticities*

	Specifications	
Response variables	(1)	(2)
γ_t	-2.7279	-2.723
	[1.027]	[1.233]
	(0.008)	(0.027)
γ_{t+4}	-1.733	-2.014
	[0.527]	[0.757]
	(0.001)	(0.008)

Notes: The coefficients are semi-elasticity measures and are calculated from coefficients presented in Table 3 and 4. Delta-method is used to calculate standard errors (square brackets), while *p-value* are reported in round parenthesis. Formally, the semi-elasticity is given by: $\Phi_1(\frac{1}{\bar{\gamma}})$, where Φ_1 is the estimated parameter of military spending in GDP from equation 14 and $\bar{\gamma}$ is the mean value of the per-capita GPD growth rate.

threat levels (Aizenman and Glick, 2006; Pieroni, 2009). This is pertinent in this context, as countries that are more likely to be involved in armed civil conflict are likely to be more prone to high military spending. If this is the case, threat is an omitted variable and may bias the estimated causal effect. To consider whether such geographical spillovers are important an informal test procedure is to compare the full sample results with a sample that excludes both countries with the highest share of military spending and those that did not experience armed (civil) conflict onset, i.e., Botswana, Namibia, Seychelles, and Togo and comparing these results with those for all countries. Table 6 (part a) shows the parameter estimates from estimating these two groups using both annual and five-year average data. The coefficients are clearly negative and significant and are close to those of the benchmark models, meaning that the nonlinearities mentioned have limited effects on the results and so do not need to be considered further.

Finally, 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 (14), or its specification at $t+5$, as evidence of the existence of potential endogeneity. Table 6 (part b) presents these estimates and the results support

Table 6: *Military spending and per-capita GDP growth rate (IV estimates; instrument: Armed conflict onset)*

Explanatory variables	Specifications (a) Sub-sample excluding highest military spending		(b) Forward lag(s) growth rate (full-sample)	
	γ_t	$\gamma_{t+1,t+5}$	γ_{t+1}	$\gamma_{t+1,t+5}$
$Military_{it}$	-2.651	-1.731	-2.752	-1.737
	[0.941]	[0.554]	[1.265]	[0.533]
	(0.005)	(0.002)	(0.018)	(0.007)
Non military$_{it}$	0.057	0.025	0.009	-0.038
	[0.090]	[0.054]	[0.113]	[0.053]
	(0.526)	(0.643)	(0.936)	(0.478)
Time fixed effect	yes	yes	yes	yes
Country-specific variables	no	no	yes	yes
Number of observations	384	345	389	350

Notes: Standard errors are in square brackets, while *p-value* are reported in round parenthesis. The vector of the control variables are listed in Appendix A and described in the footnote of the same table.

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 and 4. So the results of this section suggest that the empirical estimates in Section 6 can be reported with confidence.

8. Conclusions

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 important issue, that has not been adequately dealt with is the possible endogeneity of military spending in the growth equation. This paper has provided a novel approach to dealing with this issue. It developed an endogenous growth model that allows for the effects of different components of military spending and then 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 armed 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 armed 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 empirical analysis suggested that endogeneity was an important issue and that for this group of countries conflict onset, measured as more than 20 battle related deaths was a successful instrument, although conflict intensity, defined as a conflict reaching 1000 deaths was not. It also identifies a further potential bias in the same direction in studies not including non-military spending in the growth equation. Using IV estimation and including non military spending provided a larger significant negative effect for military spending on growth (-2.8) than would be given by an OLS estimator (-0.2). 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		
$Armed\ conflict\ (onset)_{it}$	PRIO Uppsala	1031	0.214	0.411
$Armed\ conflict\ (intensity)_{it}$	PRIO Uppsala	1031	0.157	0.364
		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		
$araland$	WDI	935	12.585	12.874
$Ln(aid)$	WDI	977	19.595	1.189
$Ln(open)$	WPT	983	4.115	0.656
$relfrac$	Fearon and Latin (2003)	921	48.606	18.710

Notes: Descriptive statistics refer to the entire time span 1998-2010, for the full set of analysed countries. Since $Armed\ conflict_{it}$ and $Armed\ conflict\ (intensity)_{it}$ are dichotomous variable the mean describes the incidence of armed conflicts in the whole sample. The control variable are: i) the logarithm of the net official development assistance and official aid received at constant 2008 US dollars ($Ln(aid)$); ii) the logarithm of openness at 2005 constant prices ($Ln(open)$); iii) Arable land as percentage of land area ($araland$); and iv) religious fractionalization index ($relfrac$).

Appendix B: Armed conflict onset in Sub-Saharan Africa

Country	Armed conflict
Treatment status	
Burundi	onset 1991 (2008)
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 armed conflict.

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