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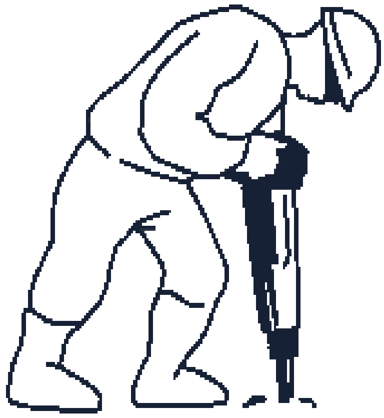

How much does military spending affect growth? Causal estimates from the World's non-rich countries

by

Giorgio d'Agostino, John Paul Dunne and Luca Pieroni

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About the Author(s) and Acknowledgments

Giorgio d'Agostino: Department of Economics, Roma Tre University (IT) & SALDRU Aliate, University of Cape Town
John Paul Dunne: School of Economics & SALDRU Associate, University of Cape Town
Luca Pieroni: Department of Political Science, University of Perugia & SALDRU Aliate, University of Cape Town - corresponding author: luca.pieroni@unipg.it.

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How much does military spending affect growth? Causal estimates from the World's non-rich countries

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Abstract

While not always a concern for the general economic growth literature, the debate over the effects of military spending on growth continues to develop, with no consensus, but a deepening understanding of the limitations of previous work. One important issue that has not been adequately dealt with, is the 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 this issue, using an endogenous growth model estimated on a large sample of 109 non-high income countries for the period 1998-2012. The empirical analysis is framed within an instrumental variable setting that exploits the increase in military spending that occurs when unrest in a country escalates to turmoil. The estimation results show that endogeneity arising from reverse causality is a crucial issue, with the instrumental variable estimates providing a larger significant negative effect of military spending on growth than OLS would. This result is found to be robust to different sources of heterogeneity and different time periods.

Keywords: Military spending, economic growth, reverse causality, instrumental variable, panel data.
JEL Classification: H00, O40, C26, C33.

1. Introduction

While not always a concern for the general economic growth literature, 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 difficulty of trying to tease out the economic processes at work. As more post Cold War data become available, the advantage of a more complex strategic environment and more movement in the data should be making the identification of any 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 empirical studies do seem to be more consistently finding a negative relation between military spending and growth (Dunne and Tian, 2013). There is, of course, 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, indeed the literature on the demand for military spending suggests it is (Dunne *et al.*, 2008), but it is also possible that these estimates reflect unmeasured shifts in military spending, which are almost certainly correlated with a higher risk of lower growth or omitted variables. 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 paper considers the likely importance of endogeneity, using an endogenous growth model for a panel of 109 non-high income countries between 1998 and 2012, undertaking a more precise analysis of the mechanism by which military spending impacts on economic growth than much of the previous literature. An increase in military spending is observed when simmering unrest escalates to turmoil and this suggest that turmoil may be a useful instrument for military spending in the growth regression. The next section provides a brief review of the relevant literature. Section 3 then presents the theoretical model, with Section 4 analysing the empirical models, discussing identification issues, namely a variable that reflects the existence of turmoil within a country. Section 5 describes the data and provides some empirical justification for the chosen instrument and 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, as discussed in Dunne and Coulomb (2008), but 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 in empirical work. Indeed, many poor countries, even those with civil wars, spend relatively little on the military and many African countries in particular 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). 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).

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 then 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).

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. 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. Moreover, 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 reported that only around 20% found a positive effect. 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[4] (Brauer 2002; d'Agostino *et al.* 2012 summarise the debate). More recently, Dunne and Tian (2013) in a survey of almost 170 studies reported that the availability of increasing post cold war data, with its higher signal to noise ratio, was 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 military expenditure-growth literature, aside from the use of GMM methods that instrument with predetermined variables. This is mainly due to the lack of obvious candidate variables that could be used as instruments. Section 4 considers these issues further, 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, we extend the framework for military and civilian spending and for the possibility that military spending is affected by shocks due to changes in the internal and external security situation. 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[5]. 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

[4]See, for example, Shieh *et al.* (2002).

[5]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).

each component. Under this government budget constraint and the assumption that the tax rate τ is constant, the steady state growth equation is, in terms of shares of resources devoted to each component ϕ_1 and ϕ_2, $[\frac{\dot{c}}{c} = \gamma]$[6]:

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

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.

As we are interested to modelling the relationship between military burden and growth to provide estimated parameters that reflect a causal link, we include the share of military spending ϕ_1 as an argument, the parameter η_1 then identifies shocks due to security changes. That is, we assume that if military spending is correlated to growth, it is because larger military spending is linked with increased insecurity and, in turn, to growth.

To investigate the properties of the model the optimal levels of the different components of government expenditure, $\phi_i = [\phi_1(\eta_1), \phi_2]$ are derived. Under the condition:

$$\sum_{i=1}^{2} \phi_i = 1 \quad \Longrightarrow \quad \phi_1(\eta_1) = 1 - \phi_2, \tag{2}$$

the effect of the component $\phi_1(\eta_1)$ on the growth rate is characterised by the relationship 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 $\frac{\dot{c}}{c} = \gamma = (1-\alpha-\beta)(1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}(\phi_1(\eta_1))^{\frac{\alpha}{1-\alpha-\beta}}$ $(1-\phi_1(\eta_1))^{\frac{\beta}{1-\alpha-\beta}} - \rho$, gives the partial derivative of γ with respect to $\phi_1(\eta_1)$:

$$\frac{\partial \gamma}{\partial \phi_1(\eta_1)} = \left\{ \left[\frac{\alpha}{\phi_1(\eta_1)} - \frac{\beta}{\phi_2} \right] \lambda \right\} \tag{3}$$

where $\lambda = (1-\tau)A^{\frac{1}{1-\alpha-\beta}}\tau^{\frac{\alpha+\beta}{1-\alpha-\beta}}(\phi_1(\eta_1))^{\frac{\alpha}{1-\alpha-\beta}}(1-\phi_1(\eta_1))^{\frac{\beta}{1-\alpha-\beta}} > 0$, and the sign of the partial derivative depends on the parameters in the squared parentheses of the equation.

For example, military spending component g_1 is classified as "productive", if the partial

[6]For an extensive description of the model, see d'Agostino *et al.* (2011).

differential of output with respect to ϕ_1, (e.g., $\frac{\partial\gamma}{\partial\phi_1(\eta_1)} \geq 0$), requires that:

$$\frac{\phi_1(\eta_1)}{\phi_2} \leq \frac{\alpha}{\beta},$$

while military spending will be classified unproductive (e.g., $\frac{\partial\gamma}{\partial\phi_1(\eta_1)} < 0$) if :

$$\frac{\phi_1(\eta_1)}{\phi_2} > \frac{\alpha}{\beta}.$$

This formulation allows the impact of an exogenous shock that leads to changes in one component of government spending (i.e., the share of military spending in GDP) to be analysed.

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 literature should not be surprising. Much of the literature has focused on estimating cross-country regressions, whereas there has been little debate about the possibility that the estimated relationships could have problems of endogeneity. Reverse causation resulting, for example, from economic growth increasing the resources available for government spending and so increasing military spending, or from omitted variables, with unobserved variables affecting economic growth and military spending simultaneously and so biasing the estimation results[7]. The theoretical endogenous growth model in section 3 suggests that excluding non-military spending could lead to a omitted variable bias. When the government budget constraint is given, a shock that increases military spending leads to changes in other forms of government spending, such as education, health, or general government spending. This implies that it is worthwhile extending the empirical model to control for any contemporaneous changes in resources across the different components of government spending.

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

[7] For example, if military spending was 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 in response to internal threats and then, later on, allocate more to productive government spending to increase growth.

as a reduced form equation:

$$\gamma_i = \beta_0 + \beta_{1,\gamma} Military_i + \beta_2 X_i + S_i + \epsilon_i \tag{4}$$

where X_i is a vector of control variables of the model, which includes non-military spending and private investment, and S_i country fixed effects, included to account for differences between countries in institutional contexts that the vector X_i does not control for. This specification would, however, ignore useful information from time variation in the data and to overcome this much recent empirical work has applied this form of model to panel data.

Using panel data methods to deal with unobserved heterogeneity will control for some types of omitted variables and can help solve some identification problems. Institutional differences across countries, for example, will have time-invariant characteristics and as Fordham and Walker (2005) show, while liberal states engage in less military spending than autocracies, the nature of government varies slowly over time, if at all. In addition, it has been found that corruption and military spending are positively correlated, with corruption acting directly on growth. This may imply that omitting corruption will emphasise the negative effects of military spending on growth, but since corruption is a persistent and time-invariant phenomenon within a country (Mauro, 2004), using panel data methods will deal with this issue.

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 may be correlated with the current growth rate. This potential reverse causality can be formalised to identify the expected negative sign for the parameter reflecting the effect of military spending on growth (i.e., $\beta_{1,\gamma} < 0$) with the feedback effects of growth on military spending, which are expected to be positive. This implies that military expenditure cannot simply be assumed to be exogenous, meaning that the OLS empirical estimates are not easy to interpret. Appendix A provides a formal exposition of the reverse causal effects applied to the military burden and growth nexus.

To deal with this issue, an instrumental variable (IV) approach can be used, but the problem is identifying suitable instruments. 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[8].

We identify and propose a structural model as a derivation of the relevant growth and military spending reduced forms, specified as:

$$Military_{it} = \theta_0 + \theta_1 Z_{it} + \theta_2 X_{it} + S_i + T_t + v_{it} \tag{5}$$

$$\gamma_{it} = \delta_0 + \delta_1 Z_{it} + \delta_2 X_{it} + S_i + T_t + u_{it} \tag{6}$$

in which Z_{it} is the instrument(s) to be used to identify the relationship between military burden and growth and the estimates of θ_1 and δ_1 are carried out accounting for time-varying unobserved effects (T_t), with X_{it} and S_i as defined above.

The structural form used to yield causal estimates is then:

$$\gamma_{it} = \Phi_0 + \Phi_1 Military_{it} + \Phi_2 X_{it} + S_i + T_t + d_{it} \tag{7}$$

where the instrumental variable (IV) estimate of the coefficient on military spending (7) is the ratio of the reduced form coefficients on military spending, that is $\Phi_1 = \delta_1/\theta_1$[9]. This implies that if the parameter Φ_1 is statistically significant, the impact of military spending on growth reflects the correction attributable to the instrumental variable, because this correlation is mainly transmitted through the military spending channel (i.e., $\theta_1 > 0$). In other words, if Z_{it} is a determinant of military spending, it can legitimately be omitted from equation (4).

In trying to find an instrumental variable for military burden, we are looking for a variable that reflects a country's 'security' situation, but these variables are notoriously difficult to find or construct. The existence of armed conflict is clearly an important factor in creating insecurity and this suggests that conflict related variables might prove useful, but the literature suggests that economic growth may also affect the onset of conflict (see Miguel *et al.* 2004; Miguel and

[8]Deaton critically evaluates the empirical studies on aid and growth, linked with quasi randomisation and criticises the rather ad hoc approach to instrument selection, shows the problems involved in finding suitable instruments and the importance of theory in seeking them.

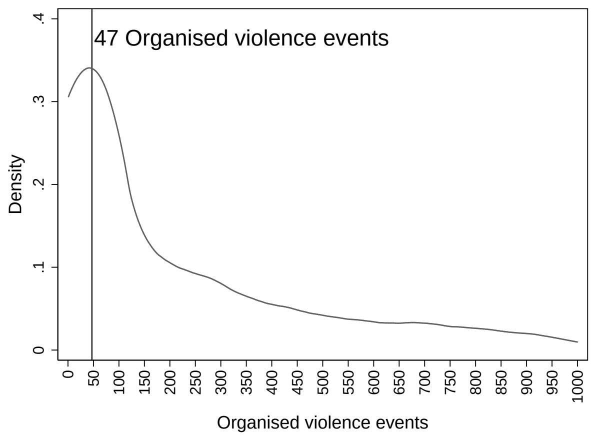
[9]Note that in the just identified case IV estimator is identical to ILS estimator. For mathematical derivation and discussion, see Angrist and Pischke (2009, pg. 121).

Satyanath 2010, 2011).

An alternative is to consider the variations in military spending that result from changes in security as measured by unrest in the country. We can reasonable proxy the magnitude of unrest at the country level by the reported events of organized violence, which is generally classified as "any incident where armed force was used by an organised actor against the government of an independent state resulting, in at least one direct death at a specific location and a specific date". This implies that the variable reflects changes in the security environment, but not reflect the destruction produced by the actions, many violent events can potentially produce only one direct death, while in other cases a single event may lead to many deaths. This has the advantage that we can distinguish data (and variables) on the events of organised violence from the conflict variables. Organised violence events, represents a "political variable" which is not directly linked with growth, while "conflict", quantified usually by the number of battle related deaths in a given violent event (Collier, 1999; Fearon and Latin, 2003), is more likely to reflect the destruction of productive assets that directly reduce economic growth. It seems reasonable to expect that dealing with a number of organised violent events would lead to an increase in military spending, once a certain threshold has been reached, which we will call turmoil. This led us to consider a pseudo-randomisation of the organised violence variable, with respect to the number of fatalities over the countries and years and to construct a dummy variable. This variable takes the value of one in each country and year, when the number of events exceeds the mode of the empirical distribution.

Data were taken from the Uppsala Conflict Data Program (UCDP), which provides information on state based organised violence incidents for the period 1989-2014. Figure 1 reports the distribution of and the mode threshold. Reducing a whole world sample to 109 non-high income countries, which form the sample for the empirical analysis in the next section, gave a mode of 47 incidents[10].

[10] In fact, since the probability of turmoil in OECD and high income non-OECD countries was close to zero, the use of the World sample may reduce the first step significant relationship in IV estimation (i.e., the relationship between turmoil and military spending).



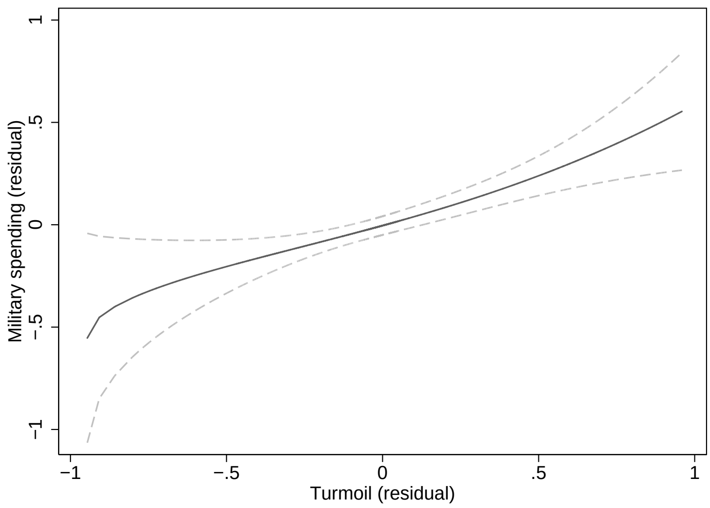
(a) Distribution of organized violence

Figure 1: The turmoil cut off

5. Estimates

To test whether turmoil can be used as an instrument, a useful first step is to consider a nonparametric local regression of country unrest on military spending using the Epanechnikov kernel method, after partialling out the fixed effects and the country specific controls. Data and variables used in the empirical section are listed in Appendix B and Figure 2 shows a positive and approximately linear relationship between the instrument and the endogenous variable, suggesting it is potentially a good instrument by this criteria (Bound *et al.*, 1995).

Figure 2: Current military spending and turmoil, conditional on time fixed effects and control variables.



Notes: This graph plots military burden residuals, obtained by a linear regression on time fixed effects and control variables, and the turmoil residuals, which are obtained using a non parametric estimation procedure conditional on time fixed effects and control variables. The continuous line is the local polynomial smoothed line and the dashed lines are the 95% confidence intervals.

A final concern that plagues most analyses of this type is the possibility that the instrument may not satisfy the exclusion restriction. While within this framework it is not possible to directly test this restriction (i.e. to test for misspecified correlations generated by economic growth on turmoil) because the proposed model is just-identified, it can be tested indirectly. This entails considering whether the proposed instrument both affects military spending in equation (5) and can legitimately be omitted from equation (4) or (7), when estimated by OLS[11]. This implicitly asks whether there are unobserved factors influencing the estimation results that would give us a valid causal estimate of the relationship rather than a correlation[12]. To test whether the turmoil variable explains a significant part of the variation in military spending, we estimated the reduced form military spending equation (5) and found it to be significant at less than the one percent level (regression 1, column 1: $\theta_1 = 0.705$) and this result was robust to the inclusion of country-specific controls ($\theta_1 = 0.623; s.e. = 0.230$). A further check can be undertaken using a "false experiment" by extending the reduced form (equation 5) to include the period ahead of the turmoil variable, (e.g., $Turmoili, t + 1$). The hypothesis that military spending is orthogonal, at time t, to the turmoil variable, at $t + 1$, is confirmed from the estimates of θ_{t+1} in column 3 ($\theta_{t+1} = 0.294; s.e. = 0.191$). So overall, these empirical checks seem to make a strong case for using turmoil as an instrumental variable for military spending in the growth equation.

Estimating the reduced form growth equation (e.g., equation 6) gave the results in Table 2, which show turmoil has a negative and significant coefficient estimate. The results in column (2), which includes country fixed effects, give an estimate of -1.739 ($s.e. = 0.786$), which is statistically significant at the 5 percent level. This is the preferred specification, as the control variable derived from the model $Non\ military_t$ and $Private - investment_{t-1}$ are statistically significant, at least at the 10 percent significance level.

Moving on to deal with the potential endogeneity, Table 3 presents IV estimation results for equation (7), using the turmoil variable as an instrument. It shows military burden to significantly and negatively affect per-capita GDP growth. As mentioned earlier, the reduced-

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

[12] To be acceptable, the instrument needs to be uncorrelated with any unobservable factors that are themselves correlated with military spending and growth.

Table 1: *Estimates of the relationship between the turmoil and military spending (Equation 5) - Dependent variable: military spending in GDP*

	Specifications		
Explanatory Variables	(1)	(2)	(3)
Turmoil_t	0.705	0.623	0.587
	(0.215)	(0.230)	(0.198)
	[0.001]	[0.007]	[0.003]
Time fixed effect	yes	yes	yes
Country fixed effects	yes	yes	yes
Regional fixed effects	yes	yes	yes
Country-specific variables	no	yes	yes
$Turmoil_{t+1}$			0.294
			(0.198)
			[0.191]
Number of observations	2329	1972	1849
Log-Likelihood	-5323.971	-2705.188	-2513.397
R^2	0.428	0.817	0.823
0.823			

Notes: Clustered standard errors at country level are in round parentheses, whereas *P-value* are reported in square brackets. Country-specific variables include non-military spending and private investment.

form estimates can provide a check for the IV method, as the structural parameter estimate for the coefficient on military burden is given by $\Phi_i = \delta_i/\theta_i$. So the point estimate for turmoil is $\Phi_1 = -2.791$ ($s.e. = 1.055$), which is equal to the ratio of the reduced form parameters in equation (5) and (6), respectively (i.e., $-1.739/0.623 = -2.791$). Further support for for the instrument is provided by a number of weak instrument tests (Bazzi and Clemens , 2013). As a first approximation, we report in curly brackets the *P-value* estimated applying the Conditional Likelihood Ratio (CLR) test of Moreira (2003). The corresponding *P-value* rejects strongly the hypothesis of weak instrument. We also list first-stage F-Wald statistic Cragg and Donald (1993) and the Kleibergen and Richard (2006) generalization to non-independently and identically distributed errors. Following the diagnostic approach developed in Yogo (2004) and implemented in Stock and Yogo (2005), we also report *p-values* for the null hypotheses that the bias in the point estimate(s) on the endogenous variable(s) is greater than 10 percent or 30 percent of the OLS bias (LM Kleibergen-Paap test). Finally, we test by the actual size (t-test)

Table 2: *Estimates of turmoil and per capita GDP growth (Equation 5) - Dependent variable: per capita GDP growth*

	Specifications	
Explanatory Variables	(1)	(2)
$Turmoil_t$	-2.306	-1.739
	(0.795)	(0.786)
	[0.004]	[0.027]
$Private - investment_{t-1}$		0.072
		(0.041)
		[0.079]
$Non\ military_t$		-0.198
		(0.096)
		[0.039]
Time fixed effect	yes	yes
Country fixed effect	yes	yes
Regional fixed effect	yes	yes
Number of observations	2329	1972
Log-Likelihood	-7254.904	-5781.338
R^2	0.198	0.230

Notes: The IV errors are two-way cluster-robust (country level and time) standard errors (Cameron and Miller, 2015). One-way clustered standard errors at country level presented for the OLS. In all the proposed specifications standard errors are in brackets whereas *p-value* are reported in square brackets.

that the point estimate(s) on the endogenous variable(s) (i.e. military burden) is equal to zero at the 5 percent significance level is greater than 10 or 25 percent. All diagnostic tests reject the hypothesis that turmoil is a weak instrument in this context.

For comparison, the third and fourth columns of Table 3 presents the OLS regression results for equation (4), which gives coefficient estimates that have the expected signs, but are considerably smaller in magnitude than the IV estimates[13]. As argued above, the OLS regression is undoubtedly affected by reverse causality. This would imply that failing to account for endogeneity in the growth equation means that military spending and the error term are likely to be positively correlated and so the OLS estimate will underestimate the negative causal effect of military spending. This is an important finding as it suggests that dealing

[13]Descriptive pooled and cross-sectional relationships between military burden and growth rate are shown in the Appendix C.

Table 3: *Estimates of military spending and per-capita GDP growth rate (IV estimates; instrument: Turmoil* $_{it}$ *) - Dependent variable: per-capita GDP growth*

	IV	IV	OLS	OLS	OLS
Explanatory Variables	[eq(7)]	[eq(7)]	[eq(4)]	[eq(4)]	[eq(4)] [instrument]
$Military_t$	-3.272	-2.791	-0.199	-0.629	-0.598
	(1.260)	(1.055)	(0.145)	(0.135)	(0.143)
	[0.009]	[0.008]	[0.170]	[0.000]	[0.000]
	{0.000}	{0.000}			
$Private - investment_{t-1}$		0.079		0.076	0.078
		(0.047)		(0.039)	(0.039)
		[0.092]		[0.055]	[0.044]
$Non\ military_t$		-0.150		-0.189	-0.151
		(0.118)		(0.098)	(0.089)
		[0.203]		[0.054]	[0.090]
Time fixed effect	yes	yes	yes	yes	yes
Country fixed effect	yes	yes	yes	yes	yes
Regional fixed effect	yes	yes	yes	yes	yes
Turmoil $_t$					-0.930
					(0.658)
					[0.158]
Number of observations	2329	1972	2329	1972	1956
Log-Likelihood	-8458.362	-5962.338	-7258.081	-5771.615	-5697.134
Cragg-Donald F stat	11.11	43.46			
Kleibergen-Paap F stat	21.51	16.45			
Kleibergen-Paap LM test	0.000	0.000			
$H_0 : size > 10\%(p - value) - KP$	0.000	0.001			
$H_0 : size > 25\%(p - value) - KP$	0.000	0.000			
$H_0 : size > 10\%(p - value) - CD$	0.009	0.000			
$H_0 : size > 25\%(p - value) - CD$	0.008	0.000			

Notes: The IV errors are two-way cluster-robust (country level and time) standard errors (Cameron and Miller, 2015). One-way clustered standard errors at country level presented for the OLS. In all the proposed specifications standard errors are in brackets whereas *p-value* are reported in square brackets. Finally, we report in curly brackets the *p-value* estimated applying the Conditional Likelihood Ratio (CLR) test of Moreira (2003).

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.

In order to show that the main transmission channel of the effects of turmoil on growth is given through the increase of military spending, we deal with in the fifth column, which adds the turmoil variable to the OLS estimates. If the parameter of the added variable is insignificant, this would suggest that misspecified correlations generated by economic growth is not correlated with the errors. The results in the fifth column of Table 3 confirm the goodness of our strategy of estimation, showing that the estimated coefficient of turmoil is not significant ($p - value = 0.158$), while the coefficient for military burden remains close to the OLS estimation of equation (4) (e.g., -0.589 instead of -0.629) and significant at the usual significant level ($p - value$ of 0.001).

6. Heterogeneous effects and robustness

Another concern is heterogeneity of the relation across countries with particular characteristics. Firstly, corruption can affect the growth rate through distortions in tax collection, the level of public expenditure and the composition of government expenditure, suggesting that corrupt government officials may come to prefer the types of expenditure that allow them to collect bribes and to keep them hidden[14]. The limited competition in defence sector provides a fertile ground for the growth of corrupt practices and so increase the cost of military activities, encourage rent seeking in the military sector and may crowd out productive investment (Gupta et al. , 2001; d'Agostino *et al.*, 2016a,b). Second, it seems reasonable that countries with natural resources are more able to afford military spending and natural resources can be a source of domestic conflict and international tension (Collier and Hoeffler, 2006; James, 2015). The military are important for supporting/protecting the extraction and sale of outputs, which could offset the expected negative impact of military spending on the growth rate that is generally found in the literature, since military spending may be positively related to resources revenues and growth. Third, institutional arrangements can shape policy and affect growth, though an autocratic government does not necessarily mean bad economic performance (Besley and Kudamatsu , 2007). It is generally argued that autocratic regimes allocate more of their economic resources to military spending than democracies (Hewitt, 1992; Sandler and Hartley, 1995; Goldsmith, 2003) and this may mislead the true relationship between military spending and growth. The current value of exports of primary commodities as a percentage of average

[14] Shleifer and Vishny (1993) suggest that large expenditures on specialised items such missiles and bridges, whose exact market value is dfficult to determine provide more opportunities for corruption.

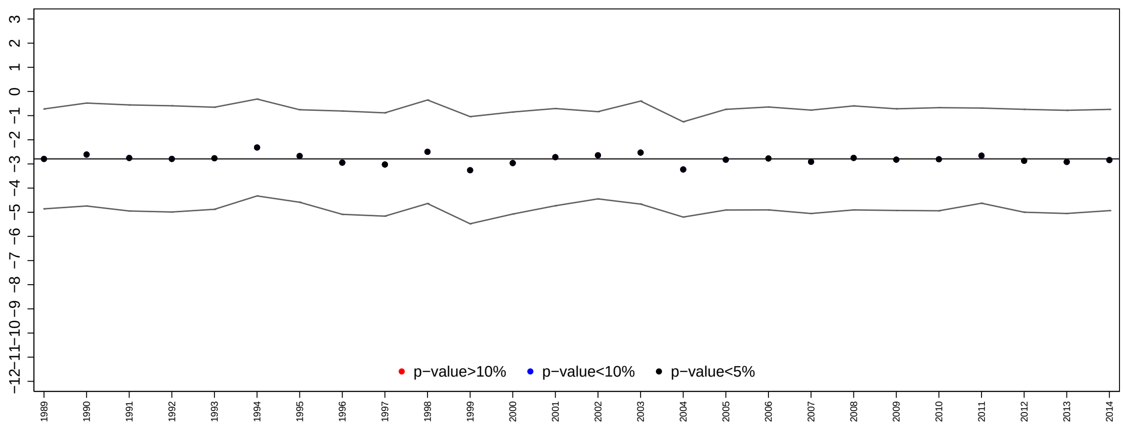
exports in the initial year (2000) is used as a proxy for the importance of natural resources to the countries. Finally, African countries do tend to show heterogeneity in cross country studies.

Given the relatively time invariant nature of the variables, three country specific dummy variables were constructed from the original indices, which for corruption and natural resources take the value 1 if the relevant index of a country is higher than the mean of the sample whereas for the form of government takes the value 1 if the country is autocratic for more years than it is democratic, and 0 otherwise [15].

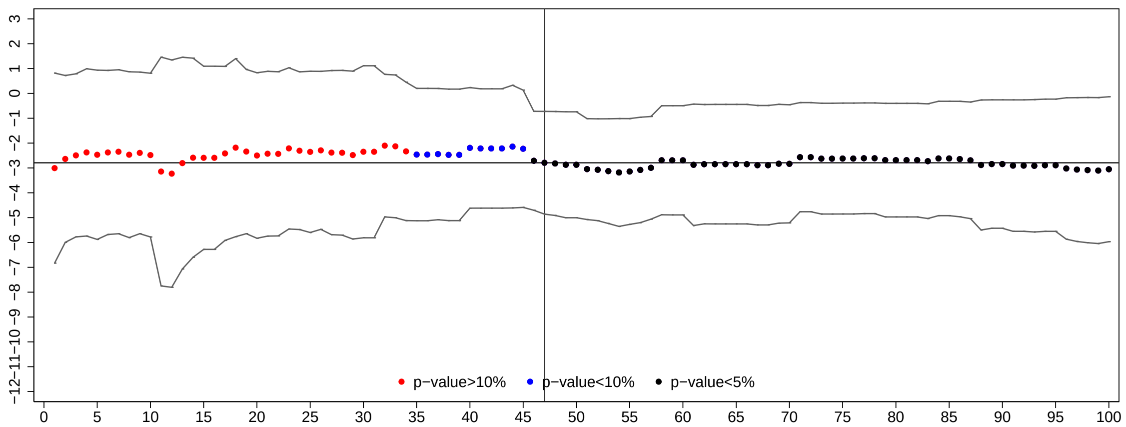
Table 4 shows the elasticities calculated from the IV estimates for the full sample and four sub-samples of countries and they confirm the general predictions. The point estimates of elasticity of military burden in the first three columns indicate that countries with a higher level of natural resources and corruption may affect less negatively growth rate (-2.291 and -2.423, respectively), whereas the impact for the countries with autocratic regime is not different from the full-sample. However, it is worth noting that the all estimates of elasticities have confidence intervals which overlie those of the baseline elasticities. Our IV estimation do appear to be robust to these specific heterogeneities, somewhat surprisingly in the case of the Africa subsample, where the level of growth rate is permanently low and military spending has a high variability induced by the presence of political instability.

As a robustness of the baseline estimates, in Figure 3 we plot the values of the parameter Φ_1 and their 95% confidence intervals. The horizontal lines indicate the full-sample estimated parameter and the black dots show when the parameter is significant at less than 5% significance level and the blue ones the parameter is significant at less than 10% significance level. The first panel shows the sensitivity of the estimated parameter to the cut-off mode used to obtain the turmoil instrument, moving across the range of >0-100 organised violent events. As shown, the points estimates are stable and for cut-off values higher than the modal value, the estimated IV parameters are always significant at less than 5%. As expected, when we use cut-off values lower about twenty five events, the IV estimator gives non-significant parameters. To explore

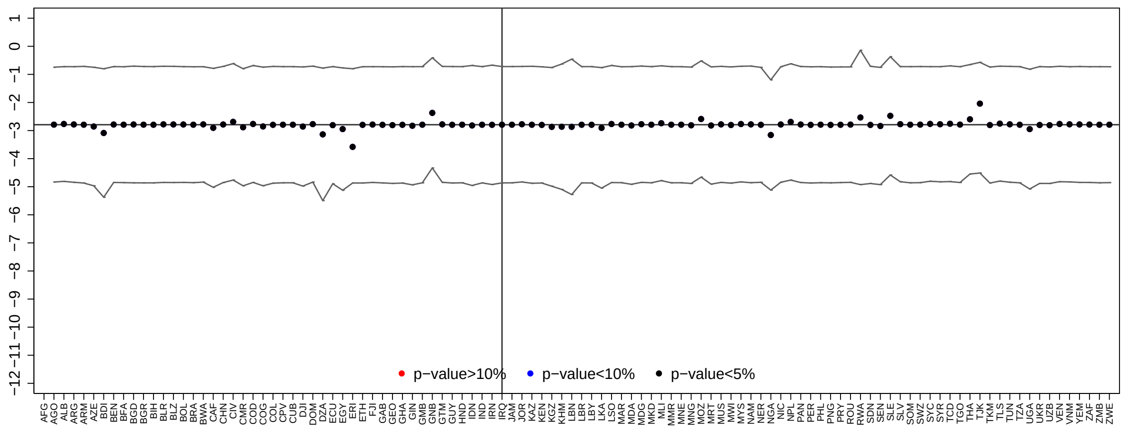
[15] Corruption is measured using the WDI control of corruption index (CCI), whereas Polity IV dataset is used to identify autocratic countries. The results were found to be robust when the median was used to obtain high corruption and abundance of natural resource countries.



(a) Sensitivity to different cut-off of battle intensity



(b) Time series



(c) Cross section

Figure 3: Stability checks on the estimated parameters

Table 4: *Estimates of elasticities of the share of military spending on growth rate by sub-samples*

	Full-sample	Corruption	Natural resources	Autocratic regime	Africa
$Military_{it}$	-2.884	-2.423	-2.229	-2.934	-2.828
	(1.195)	(1.012)	(1.003)	(1.240)	(1.205)
	[0.000]	[0.016]	[0.041]	[0.007]	[0.001]
Number of observations	2393	1102	1556	1192	1063

Notes: In all the proposed specifications, bootstrapped standard errors of elasticities are in brackets and derived from the IV errors are two-way cluster-robust (country level and time) standard errors (Cameron and Miller, 2015), whereas *p-value* are reported in square brackets. Country-specific variables include non-military spending and private investment.

the sensitivity to changes in the length of the time-series and size of the cross-section, we drop each time period or each country, re-estimate the structural model in equation 7 and report the coefficent estimates in panel b and c of Figure 3. The coefficients remain statistically significant over time and are robust to the presence of outliers[16].

7. 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 bias in the growth equation caused by military spending being endogenous. This paper has provided a novel approach to dealing with this issue. Implementing a growth model that allowed for the effects of military spending, an estimation strategy that dealt with the potential endogeneity of military spending using a measure of security as an instrument. This variable was called turmoil and was constructed from the UCDP organised state based violence data. This measure of unrest was then considered to be turmoil when the number of events was above the mode of the distribution of the variable and took the value of zero when below and one when above. We argued that the threshold would represent the point at which military spending would be

[16]The estimates obtained eliminating randomly three countries and three periods gave similar results.

increased but would not lead to any direct impact on output. How well this would work was an empirical question.

The data used to estimate the endogenous growth model was a panel of 109 non high income countries for the period 1998-2014 and the strategy used entailed estimating reduced form equations for growth and military spending, with the turmoil introduced as an exogenous shock. The structural IV estimate for growth was then the ratio of the reduced form coefficients and corresponded to the causal estimates of the parameters associated with military spending.

The results suggested that endogeneity was an important issue for the growth and military spending relationship and that turmoil was a valid instrument. Using IV estimation, gave a larger significant negative effect for military spending on growth than would be given by an OLS estimator and these estimates were robust to alternative specification, different time periods and different cross section compositions. These results imply that the damaging effects of military spending on growth are being significantly underestimated in most studies. It provides even stronger evidence that military spending really is an important fetter on economic growth. Given these results it is important that future research on the topic engages with the problem of endogeneity and that effort is made by researchers to find more useful instruments.

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Appendix A: Reverse causality in the relationship between military expenditure and growth

Suppose we have the simultaneous system for cross-section $i = 1, 2, ..., N$

$$\begin{aligned} military_i &= \beta_{1,m}\gamma_i + \epsilon_{mi} && \text{(A.1)} \\ \gamma_i &= \beta_{1,\gamma} military_i + \epsilon_{\gamma i} && \text{(A.2)} \end{aligned}$$

where $military_i$ and γ_i are the share of military expenditure and the growth rate of GDP, having concentered out all the exogenous regressors and using the Frisch- Waugh theorem. We assume that $\beta_{1,m} > 0$, i.e. fast growing economies can spend a larger share on the military sector and $\beta_{1,\gamma} < 0$, military spending reduces growth. We assume $E(\epsilon_{mi}^2) = \sigma_{mm}$, $E(\epsilon_{\gamma i}^2) = \sigma_{\gamma\gamma}$ and $E(\epsilon_{mi}\epsilon_{\gamma i}) = \sigma_{m\gamma}$. The reduced forms are

$$\begin{aligned} military_i &= [1 - \beta_{1,\gamma}\beta_{1,m}]^{-1}(\beta_{1,m}\epsilon_{\gamma i} + \epsilon_{mi}) && \text{(A.3)} \\ \gamma_i &= [1 - \beta_{1,\gamma}\beta_{1,m}]^{-1}(\beta_{1,\gamma}\epsilon_{mi} + \epsilon_{\gamma i}) && \text{(A.4)} \end{aligned}$$

Note that $[1 - \beta_{1,\gamma}\beta_{1,m}] > 0$, since $\beta_{1,\gamma}\beta_{1,m} < 0$, so the sign of γ_i on $military_i$ depends on

$$\begin{aligned} C(\gamma m) &= E(\beta_{1,m}\epsilon_{\gamma i} + \epsilon_{mi})(\beta_{1,\gamma}\epsilon_{mi} + \epsilon_{\gamma i}) && \text{(A.5)} \\ &= \beta_{1,m}\sigma_{\gamma\gamma}\beta_{1,\gamma}\sigma_{mm} + [1 + \beta_{1,\gamma}\beta_{1,m}]\sigma_{m\gamma} \end{aligned}$$

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

$$\begin{aligned} \beta_{1,m}\sigma_{\gamma\gamma} + \beta_{1,\gamma}\sigma_{mm} &> 0 \\ \beta_{1,m}\sigma_{\gamma\gamma} &> -\beta_{1,\gamma}\sigma_{mm} && \text{(A.6)} \end{aligned}$$

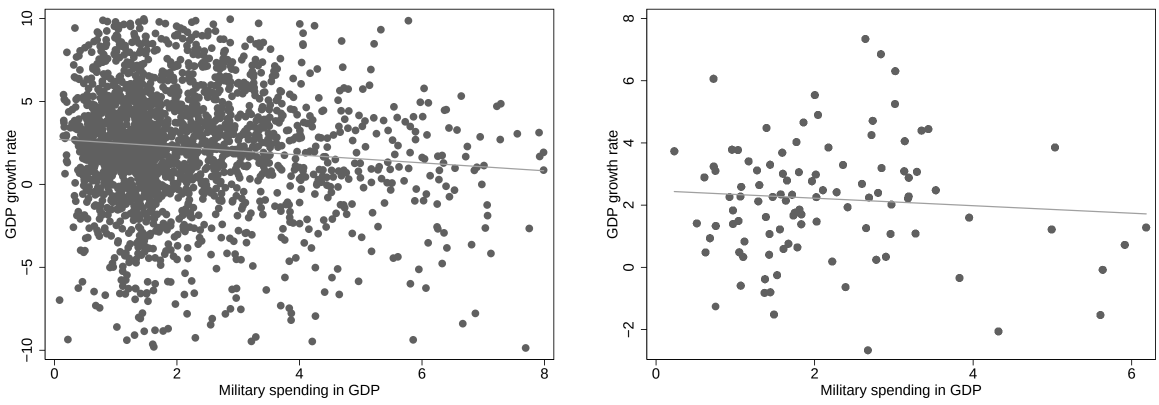
where both terms are positive since $\beta_{1,\gamma} < 0$. So the regression coefficient in a regression of growth on military burden will be positive if the effect of economic growth on military burden is greater than the effect of military burden on economic growth and *viceversa*. This also implies that the effect of the reverse causality reduces the negative effect of military burden on growth.

Appendix B: Descriptive statistics and data-source

Variable name	Source	Observations	Mean	Standard deviation
		A. Turmoil measure		
Turmoilit	UCDP	2329	16.530 %	37.153%
		B. Main economic variables		
γ	WDI	1676	2329 %	6.091%
$Military_{it}$	SIPRI	2138	16.090 %	11.719%
Non military$_{it}$	WDI-SIPRI	2137	12.863%	7.526%
Private investment	WDI	2196	21.557%	8.303%

Notes: Descriptive statistics refer to the years 1989-2014, for the full set of analysed countries. Data on unrest and turmoil are extracted by the Uppsala Conflict Data Program (UCDP), military spending in GDP ($Military_{it}$) is extracted by the Stockholm Institute of Peace research (SIPRI). From the World Bank's World Development Indicators (WDI) are collected the gross fixed capital formation in GDP (*Private investment*) and current government spending. The share of non-military spending in GDP (Non military$_{it}$) is obtained as difference between current government spending in GDP and military spending in GDP.

Appendix C: Pooled and cross-sectional relationships between military burden and growth rate



(a) Pooled (b) cross-sectional

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southern africa labour and development research unit

The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy. In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.

www.saldru.uct.ac.za
Level 3, School of Economics Building, Middle Campus, University of Cape Town
Private Bag, Rondebosch 7701, Cape Town, South Africa
Tel: +27 (0)21 650 5696
Fax: +27 (0) 21 650 5797
Web: www.saldru.uct.ac.za