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Military Expenditure, Threats, and Growth

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ABSTRACT *This paper clarifies one of the puzzling results of the economic growth literature: the impact of military expenditure is frequently found to be non-significant or negative, yet most countries spend a large fraction of their GDP on defense and the military. We start by empirical evaluation of the non-linear interactions between military expenditure, external threats, corruption, and other relevant controls. While growth falls with higher levels of military spending, given the values of the other independent variables, we show that military expenditure in the presence of threats increases growth. We explain the presence of these non-linearities in an extended version of Barro and Sala-i-Martin (1995), allowing the dependence of growth on the severity of external threats, and on the effective military expenditure associated with these threats.*

KEY WORDS: Economic growth, military expenditure, external threats, corruption

Introduction

This paper studies the long-run impact of military expenditure on growth. A well known empirical regularity is the low impact of government expenditure on growth. This result was obtained in Barro's cross-country growth regression investigation, where the coefficient of government expenditure on growth is frequently non-significant. This finding applies also for military expenditures, the impact of which is frequently found to be non-significant or negative (see Barro & Sala-i-Martin, 1995).[1]

We conjecture that these findings are due to non-linearities and omitted variable biases. Consequently, the ultimate growth effects of military expenditure can be traced only after controlling properly for the interaction between the intensity of threats and military expenditure. We validate this conjecture by estimating growth equations for a cross-section of countries

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over the period 1989–98, identifying the presence of non-linear interaction between threats and military expenditure. This is done by adding a constructed measure of military threats to the conventional growth regressions, allowing for non-linear interactions. Our findings validate the conjecture, showing that military expenditure in the presence of threats increases growth.

We provide the theoretical underpinning for the interaction between military expenditure and threats by extending Barro and Sala-i-Martin (1995) to account for the impact of military expenditure on growth. We do it in a framework that recognizes the adverse impacts of hostile external threats and actions on growth, in the presence of rent seeking and corruption. We also provide empirical evidence of non-linear interaction effects of corruption when analyzing the impact of military spending on growth.

We close the paper with discussion of possible extensions to the analysis. We suggest avenues for further empirical examination of the relation between growth and military spending. We also discuss extensions to the theoretical framework, including possible linkages between military expenditure and the economic structure through R&D spending, human capital accumulation, and learning by doing.

Threats, Military Expenditure and Growth: Empirical Evidence

We start the investigation with the following conjecture:

- The impact of military expenditure on growth is a non-linear function of the effective militarized threat posed by foreign countries and other external forces. Threats without expenditure for military security reduce growth, military expenditure without threats would reduce growth, while military expenditure in the presence of sufficiently large threats increases growth.

More specifically, denoting real growth by *gy*, military expenditures by *mil*, and a country's effective threat by *thr*, our conjecture may be expressed as

$$\frac{\partial gy}{\partial mil} = a_1 + a_2 thr; \quad a_1 < 0, \quad a_2 > 0$$
$$\frac{\partial gy}{\partial thr} = b_1 + b_2 mil; \quad b_1 < 0, \quad b_2 > 0$$

This in turn suggests a growth equation specification of

$$gy = a_1 mil + a_2(thr)(mil) + b_1 thr + \beta X; \quad a_1 < 0, \quad b_1 < 0, \quad a_2 > 0$$

where X is a set of control variables.[2] The direct effects of military spending and external threats on growth are assumed negative, while the interactive effect is positive. As empirical support for our conjecture, we provide results from estimating the growth equation above for a cross-section of countries over the period 1989–98.

Description of Data

We construct *gy* from data on real per capita GDP from the Penn World Tables, version 6.1 (PWT6.1). Transition countries are excluded from the sample. *mil* is measured as the average of the ratio of nominal military expenditures to nominal GDP over the period 1989–98, using data obtained from the World Bank *World Development Indicators* 2002 CD-ROM.[3] Since this source provides data on military spending for the years 1989–98 only, this effectively constrained the length of the time series used in constructing our cross-section averages.[4]

We proxy a country's degree of external threat by counting the number of wars and adversaries against whom it has been involved in conflict. Specifically, *thr* is defined as the number of years a country was at war with each of its adversaries during the period 1970 to 1998 summed over the set of its adversaries. Thus the external threat faced by a country rises with the number of wars in which it has been engaged, the number of adversaries it faces in each war, as well as with the number of years that each war persists.[5] This variable was constructed from data on militarized interstate disputes collected by the Correlates of War Project (COW) at the University of Michigan.[6]

We also include a standard set of control variables typically used in the empirical growth literature (e.g. Barro, 1991a,b; Barro & Sala-i-Martin, 1995, Ch. 12). These controls include the initial levels of per capita real GDP and education, the investment rate, and population growth. The initial per-capita GDP level is included to capture the empirically observed income-convergence effect on growth, where rich countries tend to grow slower than poorer countries (controlling for the other possible determinants of growth differences). The education and investment variables proxy for the levels of human and physical capital, each of which contributes to growth. Population growth is included to reflect the negative growth impact of over-population pressures on the capital-to-labor ratio.

More specifically, our control variables include *lgdp*, the log of real per capita GDP in 1975; *leduc*, the log of the number of years of schooling attained by males aged 25 and over at the secondary and higher levels in 1975; *gpop*, population growth over 1989–98; and *inv/gdp*, the average real investment/GDP ratio over 1984–88. Data on GDP levels, population, and investment/GDP ratios are drawn from PWT6.1; the education data are taken from the Barro-Lee data set (website: www2.cid.harvard.edu/ciddata/barrolee).[7]

Summary statistics for *mil*, *thr*, *gy*, and our other control variables are shown in Table 1. Military spending as a share of GDP ranges from 0 to more than 40 per cent (for Kuwait). Our threat count variable ranges from 0 to 15 (for Vietnam).[8] The unconditional correlation of *mil* and *thr* is 0.33, and the correlation conditioned on data availability for the variables in our growth equation is 0.48, implying countries with higher levels of military spending also tend to face greater external threats. Figure 1 gives a scatter plot illustrating the same positive relation between these variables (with observations indicated by three-letter country labels).[9] This finding supports our view of the importance of taking account of the interaction of military spending and the level of 'need' for military services when analyzing the impact of military spending on economic growth.

Table 1. Summary statistics

	Mean	*Std. Dev.*	*Min*	*Max*	# of cos.
mil	3.80	5.31	0.00	40.42	133
thr	0.90	2.36	0.00	15.00	133
gy	1.34	2.65	−9.09	9.56	117
lgdp	8.09	1.02	6.36	9.92	110
gpop	1.92	0.96	−0.03	4.37	116
leduc	1.03	0.91	−1.97	2.40	99
inv/gdp	14.38	7.79	2.49	44.06	111

Note: *gy* is the annual average real per capita GDP growth, 1989–98; *mil* is the military spending/GDP ratio; *thr* measures a country's external military threat; *lgdp* is the log of initial real per capita GDP; *leduc* is log of initial years of male schooling; *gpop* is population growth rate; and *inv/gdp* is the investment/GDP ratio. All variables, except *mil*, in percent.

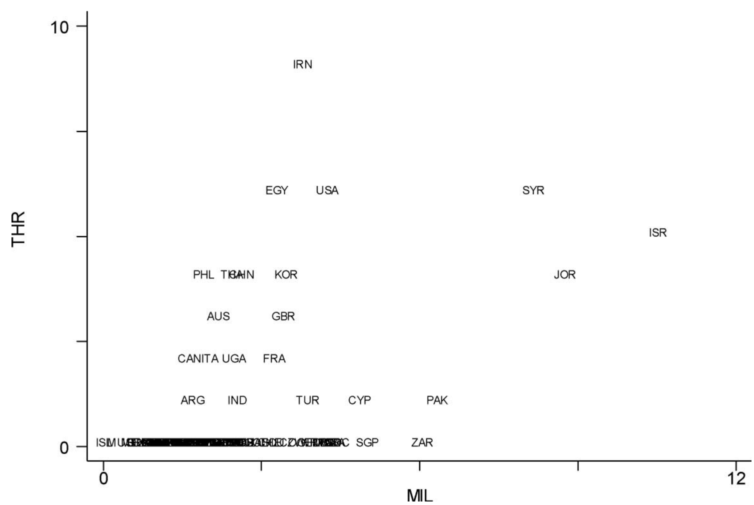

Figure 1. *Thr* versus *Mil*. *Note*: *mil* is military spending/GDP; *thr* measures a country's external military threat. Observations plotted for the 91 countries with data available for all variables in the regressions in Table 2

Our limited data and scope do not allow us to assess here the role of various political and institutional factors that may affect the magnitude and impact of military expenditures. These include the demand for security and police 'services' due to domestic unrest, the degree to which the military is controlled by civilian policy makers, the extent to which security alliances reduce resources necessary for defense, and the dual use of technology and infrastructure for civilian and military purposes. We discuss several of these issues as avenues for future research in the closing section.

Empirical Results

We test the relationship among our variables more formally by estimating our growth equation with ordinary least squares.[10] The results are shown in Table 2; we report both regular and White-heteroskedastic consistent

Table 2. Determinants of growth, military spending, and external threats

	(1)	*(2)*	*(3)*
mil	−0.08	−0.26	−0.56
	(0.15)	(0.16)	(0.20)***
	[0.18]	[0.20]	[0.30]*
thr		0.39	−0.20
		(0.15)**	(0.28)
		[0.13]***	[0.20]
mil × *thr*			0.16
			(0.06)**
			[0.07]**
lgdp	−1.59	−1.55	−1.90
	(0.44)***	(0.43)***	(0.44)***
	[0.38]***	[0.36]***	[0.37]***
leduc	0.74	0.69	0.70
	(0.43)*	(0.41)*	(0.40)*
	[0.36]**	[0.35]*	[0.34]**
gpop	−1.04	−1.04	−1.28
	(0.40)***	(0.38)***	(0.39)***
	[0.32]***	[0.33]***	[0.37]***
inv/gdp	0.13	0.12	0.14
	(0.04)***	(0.04)***	(0.04)***
	[0.04]***	[0.04]**	[0.05]***
constant	13.71	13.84	17.55
	(3.62)***	(3.50)***	(3.72)***
	[3.37]***	[3.12]***	[3.44]***
# of cos.	91	91	91
Adj R2	0.24	0.29	0.33

Notes: Estimation by OLS. Standard errors in parentheses; robust standard errors in brackets. ***indicates significance at 1%, **at 5%, *at 10%. Dependent variable is *gy*, the annual average real per capita GDP growth over 1989–98. Explanatory variables include *mil*, military spending/GDP; *thr*, a measure of a country's external military threat; *mil* × *thr*, an interaction of the two variables; *lgdp*, log of initial real per capita GDP; *leduc*, log of initial years of male schooling; *gpop*, population growth rate; and *inv/gdp*, the investment/GDP ratio.

standard errors. While the latter are more robust to concerns about heteroskedasticity, the non-robust standard errors are more efficient.

The control variables have the expected signs and are significant at conventional levels. Per capita growth depends positively on the education level and investment rate and negatively on population growth. We also find evidence of the usual conditional convergence result: countries with high initial income levels grow more slowly.[11]

The three columns of Table 2 compare the effects on growth of including our measures of military spending and external threat.

Column (1) in Table 2 shows the effect of including only the ratio of military spending to GDP. The estimated coefficient is negative, but is highly insignificant (the p level is 0.59). This result accords with that of Barro (1991a,b) and Barro and Sala-i-Martin (1995), who fail to find any significant effect of military spending on growth.[12] As shown in column (2), adding our threat measure as an explanatory variable, increases the magnitude (in absolute value) of the coefficient on military spending, but it is still not significant at conventional levels (the p-level is 0.11). Moreover, the coefficient on *thr*, though very significant, is positive, implying that external conflicts have a positive effect on growth, contrary to our expectation.

However, as shown in column (3), including an interactive term involving *mil* and *thr* provides support for our conjecture. *mil* now has a very significant (at better than 1 per cent) and negative direct effect on growth. The coefficient on *thr* is now negative, as expected (though it is not significant), implying a higher level of external threat directly reduces growth.

The coefficient on the interactive term is significant (at a 5 per cent level) and positive, as conjectured: the presence of threats (algebraically) raises the marginal impact of military expenditures on growth.

In fact, the coefficients on *mil* and $mil \times thr$ imply that for threat levels below (above) 3.5 ($=0.56/0.16$) greater military spending has an overall negative (positive) effect on growth. Quantitatively, the estimated impact of military spending ranges from a low of -0.56 for countries with no threats to a high of 0.88 for a country with the maximum threat level.[13] That is, the effect of a 1 percentage point increase in the military spending/GDP ratio varies from a *reduction* in growth by almost 0.6 of a percentage point to an *increase* in growth by almost 0.9 percentage points.

As a check on the results, the growth equation was re-estimated by interacting *mil* with two separate dummy variables: one for countries facing low threats, i.e. with values of *thr* less than 3.5 (the break point level identified above), and the other for countries with high threat levels, i.e. with values of *thr* greater than 3.5. (Separate intercepts for low and high threat countries were also included in place of a common constant term.) This specification results in an estimated coefficient for *mil* of -0.47 (s.e. $= 0.20$) in the low threat range and of 0.26 (s.e. $= 0.27$) in the high threat range. That is, the effect of *mil* on growth is negative when *thr* is low and positive when *thr* is high.[14] These estimated coefficients are jointly significantly different from zero (p-value = 0.04) and also significantly different from each other (p-value = 0.03). Thus this piece-wise linear specification implies a relationship similar to that found in the specification including the interaction term between *mil* and *thr*.

Figures 2 and 3 graphically illustrate the relationship among growth, military spending, and threats. Figure 2 shows the partial relation between growth and military spending, as implied by the regression from column 3 of Table 2, with the interaction effect of *mil* and *thr* included. The horizontal axis plots military spending for the countries included in the regression sample. The vertical axis shows the corresponding growth rate of GDP after filtering out the effects explained by all explanatory variables other than *mil*, including the direct effect of *thr* and the interactive term.[15] The negative slope apparent in the scatter plot is consistent with the negative relation reported for the regression; that is, growth falls with higher levels of military spending, given the values of the other independent variables (including the interaction effect).

Figure 3 shows the partial relations between the growth rate and military spending ratio for the low and high ranges of the threat variable identified earlier. In the top panel, where *thr* is below 3.5, the estimated relation is negative. In the bottom panel, where *thr* is above 3.5, the estimated relation is positive.

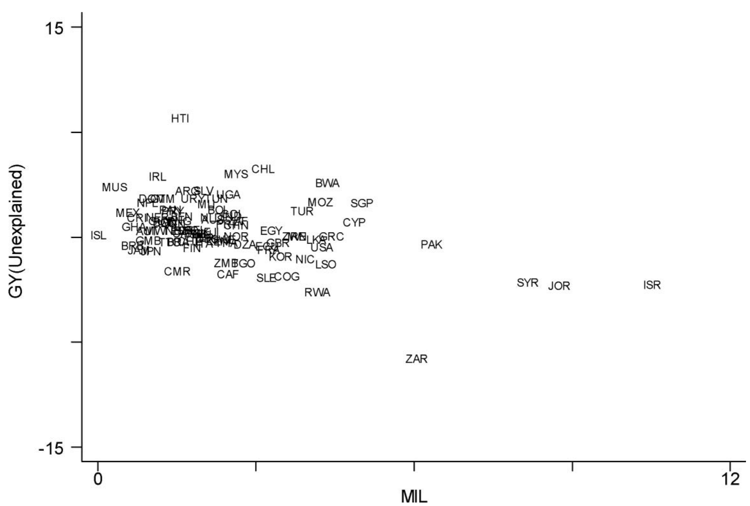

Figure 2. Conditional correlation between growth and military spending, controlling for external threats. *Note*: Conditional correlation calculated from regression for *gy* that contains all of the explanatory variables in Table 2, column (3), including *mil*, *thr*, and *mil* × *thr*. The variable plotted on the vertical axis is the unexplained part of *gy* after filtering out the effects of all of the explanatory variables except *mil*

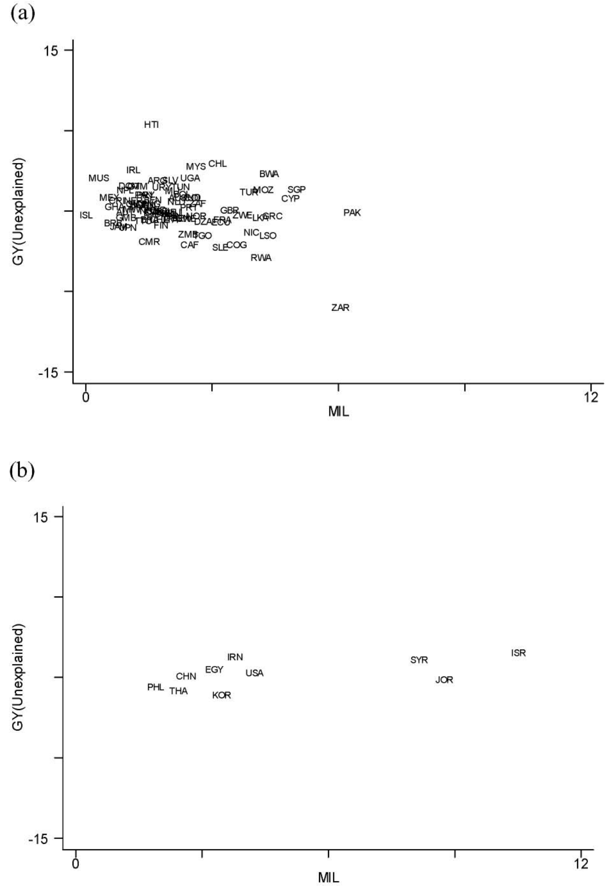

Figure 3. Conditional correlation between growth and military spending (a) Low external threat countries (b) High external threat countries. *Note*: Conditional correlation calculated from a regression for *gy* that contains all of the growth variable controls in Table 2 as well as $mil \times lowthr$ and $mil \times highthr$, where *lowthr* is a dummy defined equal to 1 for countries with a level of $thr < 3.5$ and *highthr* is a dummy defined equal to 1 for countries with level of $thr > 3.5$. (The dummies are also included as separate intercepts in the regression.) Panel a plots on the vertical axis the unexplained part of *gy* after filtering out the contribution of all variables except $mil \times lowthr$; panel b filters out the effects of all variables except $mil \times highthr$

Theoretical Model

We model the interaction of growth, military spending, and external threats by extending Barro (1990). To simplify, we assume zero population growth. Output per worker is impacted positively by infrastructure supplied by the public sector, and negatively by the magnitude of the external threat. The reduced form of output is

$$y = A(k)^{1-\alpha} (g)^{\alpha} f \tag{1}$$

where A is an exogenous productivity factor, k is the capital/labor ratio, g is the ratio of government (non-military) spending on infrastructure relative to labor, and $1-f$ measures the output cost of the threat posed by foreign rivals' actual or potential hostile actions. We assume that this cost depends negatively on domestic military expenditures and positively on an index of the magnitude of the threat; for simplicity we adopt the following functional form:[16]

$$f(g_m, z) = \frac{g_m}{g_m + z}; \quad f_{g_m} > 0, \ f_z < 0, \ f(0,z) = 0, \ f(\infty, z) = 1, \ \ 0 < f < 1 \tag{2}$$

where g_m is domestic military expenditure and z is the foreign threat level. Note that this specification implies that z is measured in units comparable to that of domestic military expenditure so that g_m and z may be aggregated.[17]

Our model abstracts from a number of possible considerations. First, we assume that the economy is always in a long-run full employment steady state. Hence we do not address transitional dynamics, according to which, fiscal spending on military may reduce excess capacity and unemployment during the transition to the steady state. Second, since our model consists of a single sector, we abstract from possible technological spillovers from military goods output to the production of goods in a distinct civilian sector. We discuss this as a possibility for future research in the conclusion section.

Corruption may also be introduced into the model as activity that taxes fiscal expenditures on military and non-military government spending at a rate of t_c. Hence, output with corruption is

$$y = A(k)^{1-\alpha}(g[1 - t_c])^{\alpha} \frac{g_m[1 - t_c]}{g_m[1 - t_c] + z} \tag{3}$$

We denote the ratio of military to non-military infrastructure expenditure by ϕ,

$$g_m = \phi g \tag{4}$$

Thus, the total fiscal outlay on both military and non-military spending is $(1 + \phi)g$.[18]

The rest of the model's specification is identical to that of Barro (1990). It is assumed that capital does not depreciate. The fiscal outlay is financed by a proportional tax τ:

$$(1 + \phi)g = \tau y \tag{5}$$

The representative agent's preferences are

$$U = \int_0^\infty \frac{c^{1-\sigma} - 1}{1 - \sigma} \exp(-\rho t) \mathrm{d}t \tag{6}$$

Following the methodology described in Barro (1990), it follows that the output growth rate is

$$\gamma = \frac{\dot{y}}{y} = \frac{1}{\sigma}\left[(1 - \tau)\frac{\partial y}{\partial k} - \rho\right] \tag{7}$$

The optimal pattern of taxes and spending (denoted by $\tilde{\tau}$, $\tilde{\phi}$) that determines the size of the military sector and maximizes the growth rate is given by[19]

$$\tilde{\tau} = \alpha(1 + \tilde{\phi}) \tag{8a}$$

$$(\tilde{\phi})^2 \alpha[\alpha(1 - t_c)]^{\frac{1}{1-\alpha}}[1 - \alpha\tilde{\phi}]^{\frac{\alpha}{1-\alpha}} A^{\frac{1}{1-\alpha}} = \frac{z}{k} \tag{8b}$$

Equation (8a) equates the tax (rate $\tau = (g + g_m)/y$, and thereby also the government's expenditure share) to the output elasticity with respect to the marginal product of non-military spending, α, magnified at the rate ϕ (the ratio of military to non-military government expenditure).[20] In the absence of military spending, equation (8a) reduces to $\tau = \alpha$, the standard production efficiency condition, as derived by Barro (1990). From equation (8b) we can infer that the military expenditure ratio, ϕ, depends positively on the external threat (normalized by the domestic stock of capital), positively on the corruption level, and negatively on the productivity level:

$$\tilde{\phi} = \tilde{\phi}(z, t_c, A); \quad \tilde{\phi}_z > 0, \ \ \tilde{\phi}_{t_c} > 0, \ \ \tilde{\phi}_A < 0; \quad \tilde{\phi}(0, t_c, A) = 0 \tag{9}$$

Correspondingly, from equation (8a) it follows

$$\tilde{\tau} = \tilde{\tau}(z, t_c, A); \quad \tilde{\tau}_z > 0, \ \ \tilde{\tau}_{t_c} > 0, \ \ \tilde{\tau}_A < 0$$

Figure 4 plots the relation between military spending and the threat level implied by equations (8b) and (9).[21] In the absence of threats, $z = 0$, then $\tilde{\phi} = 0$, i.e. the optimal amount of military spending is zero. For positive threat levels, $z > 0$, however, $\tilde{\phi} > 0$, i.e. the optimal level of military spending is positive. As the threat level increases, the optimal amount of military spending increases monotonically. Figure 4 also illustrates the effect of parametrically increasing the corruption rate, t_c. The solid line depicts the benchmark relation between ϕ and z (for $t_c = 0.1$); the dashed line depicts the effect of increasing the corruption rate (to $t_c = 0.2$). Evidently, higher

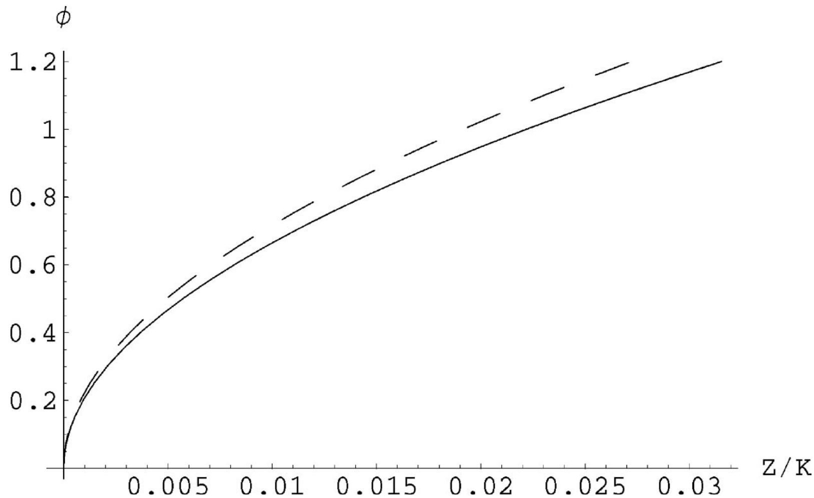

Figure 4. Optimal military spending and external threat level. *Note*: ϕ is the optimal ratio of military spending to non-military spending; z/k denotes the external threat level (normalized by the capital stock). The plots are calibrated by assuming $A = 1$, $\alpha = 0.2$, and t_c set equal to 0.1 (solid line) or 0.2 (dashed line)

corruption implies a higher optimal level of military spending for any given threat level.

A useful characterization of equilibrium government spending is that the optimal share of military expenditure is proportional to the output cost of external threats, $1 - f$ (see the appendix for the derivation):

$$\tilde{\phi} = \frac{1 - f}{\alpha} \tag{10}$$

In the absence of threats, the optimal level of military spending is zero, the output cost of threats is zero ($f = 1$), and output is a standard CRS function of k and g (see equation (1)). Correspondingly, the optimal tax rate ($\tilde{\tau}$) equals the output share of government services (α), and is independent of scale effects (as follows from equations (8a) and (10)). The presence of threats and hostile actions, however, implies positive military spending and output costs ($f < 1$), and adds a non-linear multiplicative term (f) to output.

This in turn adds a scale consideration to the design of optimal tax and spending rates, summarized by (see the appendix):

$$\alpha\tilde{\phi} = 1 - f = \frac{z}{\tilde{g}_m(1 - t_c) + z} \tag{11}$$

where $\tilde{g}_m = \frac{\tilde{\phi}\tilde{\tau}\tilde{y}}{1+\tilde{\phi}}$. The optimal ratio of military to non-military government spending ($\tilde{\phi}$) times the output share of nonmilitary spending (α) equals the output cost of external threats $(1-f)$, which in turn equals the magnitude of the foreign threat (z) relative to the aggregate effective military expenditure by the domestic country and its foreign rival ($\tilde{g}_m(1-t_c)+z$), where 'effective' implies net of corruption tax. Consequently, an exogenous increase in the foreign threat level, z, increases the optimal spending and tax rates, $\tilde{\phi}$ and $\tilde{\tau}$.

Hence, the foreign hostility level impacts growth adversely due to two compounding effects: the direct adverse growth effect associated with the resultant drop of the marginal product of capital (see equation (7)), magnified by the adverse effects associated with the higher tax rate induced by lower productivity. Applying the same logic, it follows that higher corruption (t_c) and lower domestic productivity (A) increase military spending and the optimal tax rate and reduce growth. Accordingly, we can derive the following reduced-form expression for optimal output growth:

$$\tilde{\gamma} = \tilde{\gamma}(z, t_c, A); \quad \tilde{\gamma}_z < 0, \;\; \tilde{\gamma}_{t_c} < 0, \;\; \tilde{\gamma}_A > 0$$

In addition, we may determine that (see the appendix for the derivation)

$$\frac{\partial \tilde{\gamma}}{\partial \tilde{\phi}} < 0 \quad \text{and} \quad \frac{\partial^2 \tilde{\gamma}}{\partial \tilde{\phi} \partial z} > 0$$

thus confirming the nonlinear theoretical relationship between growth and military spending that we conjectured and tested empirically in the previous section.

We illustrate these results in Figure 5, which plots the corresponding relation between the optimal levels of growth and military spending, while holding constant the levels of external threat and corruption.[22] Higher military spending reduces growth, ceteris paribus. A higher threat level shifts the entire locus upward.

Military Expenditure, Corruption, and Growth: Empirical Evidence

Our theoretical model suggests that the relation between military expenditure and growth also depends on corruption and rent seeking behavior. In particular, by acting as a tax on fiscal expenditures, corruption raises the desired level of military spending. Accordingly, we conjecture:

- The impact of military expenditure on growth is a non-linear function of the level of corruption. Military expenditure in the presence of corruption reduces growth.

In this section we present some empirical evidence concerning the association between military spending, corruption, and growth.[23] We initially abstract from the role of external threats considered in the empirical analysis of the second section.

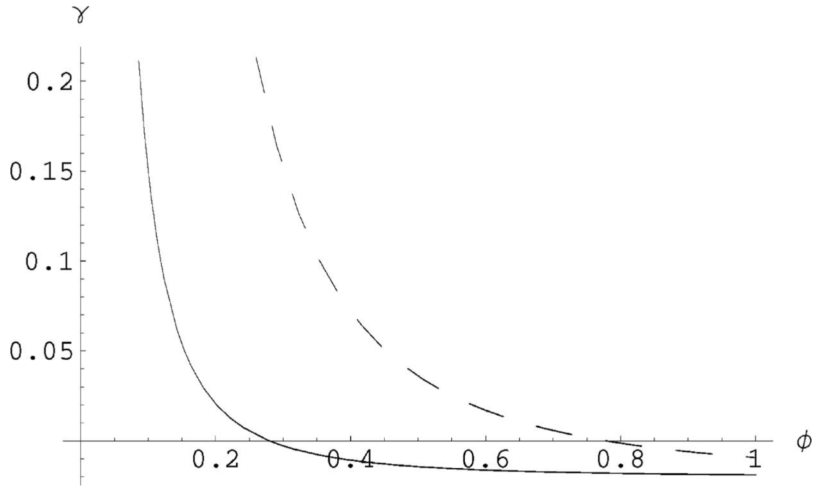

Figure 5. Optimal growth and military spending. *Note*: γ is the optimal growth rate; ϕ is the optimal ratio of military spending to non-military spending. Plots are calibrated by assuming $\alpha = 0.2$, $t_c = 0.1$, $\sigma = 1$, $\rho = 0.02$, $z/k = 0.0001$ (solid line), $z/k = 0.001$ (dashed line), and parametrically varying A to determine $\tilde{\phi}$ through equations (8a) and (A10) in the appendix

As our measure of corruption, we employ the index constructed by Tanzi and Davoodi (1997) based on data from Business International (BI) and the International Country Risk Guide (ICRG). The Tanzi–Davoodi measure ranges from 0 (most corrupt) to 10 (least corrupt), and hence may be interpreted as an increasing index of 'good government' practices.[24] The explanatory variable *goodgov* is defined as the average level of this index over the period 1989–95.[25] The unconditional correlation of *mil* and *goodgov* is -0.19, implying that the military spending share of GDP tends to fall with good government and rise with corruption. However, when the sample is restricted only to countries with data available for all of the variables in our growth equation, the correlation is only -0.02.[26] Figure 6 plots the good government index against the ratio of military spending to GDP for this restricted sample. No clear relationship is apparent in the scatter.

Table 3 reports the effects of including corruption in our model of growth, along with the same control variables used in Table 2; a dummy for sub-Saharan African countries has also been added to control for possible omitted regressors that may explain the relatively low growth of countries in this region.

As column (1) of Table 3 indicates, the coefficient on our good government variable is positive and significant, implying better government and less corruption has a positive effect on growth. An improvement in the

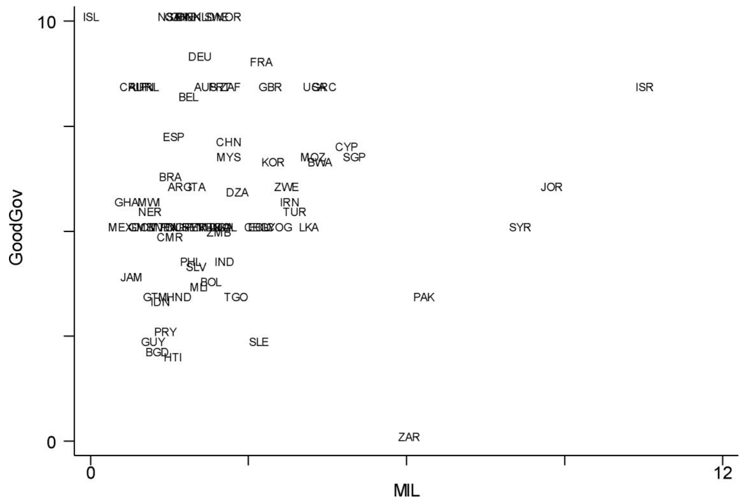

Figure 6. *Goodgov* versus *mil*. *Note*: *mil* is military spending/GDP; *goodgov* measures a country's level of good government. Observations plotted for the 81 countries with data available for all variables in the regression results reported in column (3) of Table 3

good government index by one unit (on a scale of 0 to 10) is estimated to raise the growth rate by 0.50 percentage points.[27] This finding accords with that of Mauro (1995), among others.[28] Column (2) indicates that the significance of corruption is robust to adding the ratio of military spending to GDP, but the latter is highly insignificant (the p level is 0.85). However, as shown in column (3), including an interactive term involving *mil* and *goodgov* provides support for a non-linear relation between military spending, corruption, and growth. *mil* now has a very significant (at better than 1 per cent) and negative direct effect on growth. The direct effect of *goodgov* on growth is now insignificant, but the coefficient on the interactive term is significant (at a 1 per cent level) and positive, implying military expenditure in the presence of better government raises growth.[29] This result is consistent with our model.

As a robustness check on our measure of corruption we also used the aggregate governance indicator of Kaufmann *et al.* (1999a,b), constructed from six separate indices: 'voice and accountability', 'political instability and violence,' 'government effectiveness,' 'regulatory burden,' 'rule of law,' and 'graft.' The index and its subindices are all defined on a scale of −2.5 to 2.5, with higher values indicating better governance.[30] These data are only available for 1996 onwards, near the end of our sample period; we used the 1996 values in our estimation. The results with the aggregate governance indicator *governance* are reported in Appendix Table A1 and are similar to those with our benchmark Tanzi–Davoodi measure.[31]

Table 3. Determinants of growth, military spending, and corruption

	(1)	*(2)*	*(3)*
mil		−0.03	−1.27
		(0.14)	(0.31)***
		[0.16]	[0.36]***
goodgov	0.51	0.50	−0.04
	(0.17)***	(0.17)**	(0.20)
	[0.27]*	[0.27]*	[0.17]
mil × *goodgov*			0.20
			(0.05)***
			[0.05]***
lgdp	−2.54	−2.48	−2.51
	(0.46)***	(0.47)***	(0.42)***
	[0.44]***	[0.44]***	[0.34]***
leduc	0.20	0.17	0.18
	(0.45)	(0.46)	(0.41)
	[0.45]	[0.45]	[0.41]
gpop	−0.88	−0.81	−0.91
	(0.32)***	(0.37)**	(0.33)***
	[0.32]***	[0.33]**	[0.29]***
inv/gdp	0.04	0.05	0.07
	(0.04)	(0.04)	(0.04)*
	[0.06]	[0.06]	[0.05]
Africa	−3.81	−3.79	−3.35
	(0.76)***	(0.77)***	(0.70)***
	[1.13]***	[1.19]***	[0.79]***
constant	21.02	20.46	23.84
	(3.48)***	(3.56)***	(3.29)***
	[3.51]***	[3.49]***	[3.24]***
# of cos.	83	81	81
Adj R2	0.44	0.42	0.53

Notes: Estimation by OLS. Standard errors in parentheses; robust standard errors in brackets. ***indicates significance at 1%, **at 5%, *at 10%. Dependent variable is *gy*, the annual average real per capita GDP growth over 1989–98. Explanatory variables include *mil*, military spending/GDP; *goodgov*, the Tanzi–Davoodi measure of corruption (higher values denote less corruption and better government); *mil* × *goodgov*, an interaction of the two variables; *lgdp*, log of initial real per capita GDP; *leduc*, log of initial years of male schooling; *gpop*, population growth rate; *inv/gdp*, the investment/GDP ratio; and *Africa*, dummy for sub-Saharan African countries.

The coefficients on *mil* and *mil* × *goodgov* imply that for threat levels above 6.35 (= 1.27/0.20) greater military spending has an overall positive effect on growth.[32] Analogously to our analysis of the role of external threats, the growth equation was re-estimated by interacting *goodgov* with separate dummy variables for countries with low and high levels of *goodgov*, i.e. with values of *goodgov* less than and greater than the cutoff value of 6.35, respectively. (Separate intercepts were also included in place of a common constant term.) This specification results in an estimated coefficient for *goodgov* of −0.35 (s.e. = 0.17) in the low range and of 0.26 (s.e. = 0.19) in the high range. That is, the effect of *mil* on growth is negative when *goodgov* is low and positive when it is high. These estimated coefficients are jointly significantly different from zero (p-value = 0.03) and also significantly different from each other (p-value = 0.01). Thus this piecewise linear specification, implies a relationship similar to that found in the specification, including the interaction term between *mil* and *thr*.

Figure 7 plots the partial relation between growth and military spending, as implied by the regression from column (3) of Table 3. The vertical axis shows the growth rate of GDP after filtering out the effects explained by all explanatory variables other than *mil* (including the direct effect of *goodgov* and the interactive term). The negative slope apparent in the scatter plot is consistent with the negative relation reported for the regression; that is, growth falls with higher levels of military spending, given the values of the other independent variables, including corruption.

These results highlight the need to control for nonlinear interaction effects of corruption when analyzing the effect of military spending on growth.

We conclude this section by simultaneously considering the empirical effects of external threats and corruption on military spending and growth. We do so by dividing our sample into two subsamples according to the mean level of corruption, 6.00. Table 4 reports the results of estimating the nonlinear effects of military spending and threats on growth for each of these two samples. As shown in Column (1), the coefficients on *mil* and *mil* × *thr* have the expected negative and positive signs, respectively, for 'high' corruption countries, i.e. the countries with low indices of good

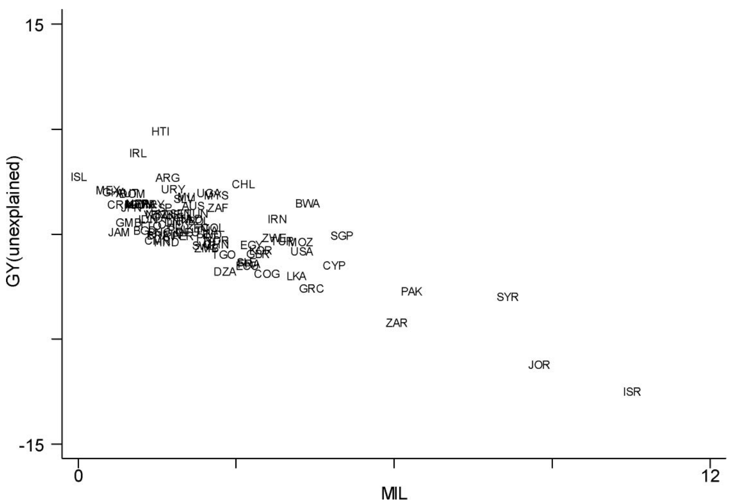

Figure 7. Conditional correlation between growth and military spending, controlling for corruption. *Note*: Conditional correlation calculated from regression for *gy* that contains all of the explanatory variables in Table 3, column (3), including *mil*, *goodgov*, and *mil* × *goodgov*. The variable plotted on the vertical axis is the unexplained part of *gy* after filtering out the effects of all of the explanatory variables except *mil*

Table 4. Determinants of growth, military spending, external threats, and corruption

	Low goodgov (1)	*High goodgov (2)*
mil	−0.81	0.19
	(0.30)***	(0.22)
	[0.45]*	[0.18]
thr	−0.31	−0.06
	(0.43)	(0.26)
	[0.35]	[0.27]
mil × *thr*	0.22	0.00
	(0.10)**	(0.06)
	[0.11]*	[0.05]
lgdp	−1.89	−2.40
	(0.64)***	(0.53)***
	[0.56]***	[0.52]***
leduc	0.87	1.13
	(0.60)	(0.71)
	[0.48]*	[0.64]*
gpop	−1.99	−0.42
	(0.59)***	(0.37)
	[0.57]***	[0.39]
Inv/gdp	0.06	0.10
	(0.09)	(0.04)***
	[0.07]	[0.04]**
constant	20.27	19.95
	(5.43)***	(4.40)***
	[5.48]***	[4.85]***
# of cos.	49	32
Adj R2	0.36	0.52

Notes: Estimation by OLS. Standard errors in parentheses; robust standard errors in brackets. ***indicates significance at 1%, **at 5%, *at 10%. Dependent variable is *gy*, annual average real per capita GDP growth over 1989–98. Explanatory variables include *mil*, military spending/GDP; *thr*, external threat; *mil* × *thr*, interaction variable; *lgdp*, log of initial real per capita GDP; *leduc*, log of initial years of male schooling; *gpop*, population growth rate; and *inv/gdp*, investment/GDP ratio. Subsamples defined by *goodgov* level, the Tanzi–Davoodi measure of corruption (higher values denote less corruption and better government) relative to sample mean: low goodgov (*goodgov* < 6.0) and high goodgov (*goodgov* > 6.0).

government (*goodgov* < 6.0). For this subsample, the estimated coefficient for *mil* is −0.81 and significant at 1 per cent; the coefficient on the interaction term is 0.22 and significant at better than 5 per cent.[33] In contrast, for the 'low' corruption countries (i.e. *goodgov* > 6.0), the coefficients on *mil* and the interaction term are insignificant (and the coefficient on *mil* is actually positive in sign). Thus, the effects of *mil* on growth in our sample appear to hold primarily for countries with greater corruption.

Discussion and Future Research

Our theoretical model suggests that military expenditure induced by external threats should increase growth (using the proper controls), while military expenditure induced by rent seeking and corruption should reduce growth. We have confirmed the basic conjectures implied by the theoretical model regarding the nonlinear relation between military spending, corruption, and growth in a cross-country regression growth analysis.

We close the paper with an overview of limitations, and issues left for future research. Our empirical research was constrained by the limited availability of data, inducing us to focus on a relative short time span, with limited information on the variables of interest. Short of having the luxury of better and longer data, there is no obvious way to deal with the robustness constraints imposed by the shortness of the sample. Hence, the results should be taken only as suggestive of the deeper structure linking military expenditure, threats, and growth. With better and longer data, it would be useful to analyze the role of political factors, such as the degree of political stability, the occurrence of civil wars and internal threats, the political orientation of the government, and the political power of the military in society.

Our analysis suggests a number of paths of future research concerning the effect of military activity on economic growth through its impact on the rest of the economy. Various channels by which military spending can influence the civilian economy have been discussed in the literature. The defense sector can crowd out resources for consumption and investment on the demand side and take away skilled labor and capital inputs from civilian production on the supply side. It can also train workers through the provision of education, particularly in developing economies.[34] A particularly promising avenue of future research is to model and test the possibility that military expenditures generate growth externalities. Possible channels leading to potential positive externalities include R&D and human capital formation as well as technology spillovers. Negative externalities may arise from corruption, or from wage effects on the non-traded goods sectors through 'Dutch Disease' effects.[35]

One possible approach to introduce externalities is to apply a Lucas (1993) variant of a two-sector growth model, with one sector producing final output and the other sector producing human capital, which in turn is used as an input in final output production. Final output growth would then be dependent on human capital, the accumulation of which depends on education costs and learning-by-doing effects. In this model, low-income countries may under-invest in human capital because of capital market imperfections, such as prohibitively high education costs and a low initial endowment of human capital. In such countries, the wish to promote greater military capability may induce the government to engage in activities that effectively subsidize the formation of human capital, addressing indirectly the distortions induced by the capital market imperfections. If these effects were powerful enough (and if the military expenditure does not lead to countervailing adverse effects due to corruption and rent seeking), the net outcome could be growth enhancing.

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Notes

1 For an overview of the literature on defense expenditure and growth see Ram (1995). See also Chowdhury (1991), Mintz and Stevenson (1995), Landau (1996), and Knight *et al.* (1996).

2 For simplicity, a_2 is constrained equal to b_2. These coefficients would differ in circumstances where growth is impacted by higher moments of *mil* and *thr*.

3 The World Bank reports the ratio of military expenditures to GNP; we converted these figures into ratios relative to GDP. The source of the World Bank data on military spending is the Arms Control and Disarmament Agency (ACDA). While the ACDA has reported figures for 10-year rolling periods in its (more or less) annual publication *World Military Expenditures and Arms Transfers* as far back as the 1960s, various problems of consistency must be addressed before they can be assembled into a single panel time series. The main problem concerns how the ACDA converts local currency spending data into current or real dollar terms for comparison across countries and time; this problem is much less severe when the spending data is scaled by GDP. An alternative source sometimes used by other researchers in this area is the Stockholm International Peace Research Institute (SIPRI). However, the SIPRI data face consistency issues as well; moreover, its country coverage is smaller than that provided by the ACDA. For a comparison of problems with military spending data from various sources, see Happe and Wakeman-Linn (1994) and Lebovic (1998); the latter finds that the ACDA data we use are less biased than SIPRI data.

4 Our analysis focuses on the cross-section association of military spending and growth. Expanding the time dimension of the dataset would permit consideration of the question concerning how stable is the military spending and its determinants. For example, Davoodi *et al.* (2001) find that declining international tensions with the fall of the Berlin Wall and the end of the Cold War contributed to a so-called 'peace dividend' in the form of lower military spending that enabled a higher share of government spending on non-military purposes. However, Dunne and Perlo-Freeman (2003) find little evidence of much change in defense burdens for a sample of developing countries. See also Knight *et al.* (1996), Landau (1996), and Mintz and Stevenson (1995).

5 Possible permutations of this measure include weighting conflicts by their intensity or by the timing of their occurrence, including potential threats from neighbors or other countries that did not manifest themselves in actual wars over the period, and taking account of the military capabilities of actual or potential adversaries. Another possible extension of our analysis is taking account of the occurrence of civil wars and internal threats that may also influence the magnitude of military spending. Murdoch and Sandler (2002), for example, find that civil wars have a significant, but modest, influence on growth.

6 We use Zeev Maoz's dyadic data set DYMID1.1, a revised version of the COW dataset for MID2.1 (webpage: http://spirit.tau.ac.il/zeevmaoz). This data set codes the level of hostility reached in a given country's conflict with other opposing state(s), where 2 = threat of force, 3 = display of force, 4 = use of force (short of war), and 5 = war. We construct our threat variable with disputes of hostility level 5, which generally involve more than 1000 battle

deaths. The data set is extended from 1992 through 1997 with information on 'Major Episodes of Political Violence, 1946–1999' from the University of Maryland's Center for Systemic Peace (CSP) and *The Statesman's Yearbook* (Available at: http://members.aol.com/CSPmgm/cspframe.htm).

[7] The education data are available for only 99 countries and are the main constraint on the number of countries included in our cross-section regression analysis.

[8] Kuwait and Vietnam are both eliminated when the sample is conditioned on the availability of all of the variables entering into our growth equation specification. In the latter case, Israel is the country with the highest level of *mil* (10.5 per cent of GDP) and Iran is the country with the highest value of *thr* (9).

[9] The observations are conditioned on data availability for all of the variables in the estimated growth equation.

[10] We address concerns about endogeneity by lagging our explanatory variables relative to the period of construction of our left-hand side variable *gy*. The results are not sensitive to omitting individual right-hand side variables, such as population growth or the investment/GDP ratio.

[11] Our estimated conditional rate of convergence ranges from 1.6 to 1.9 per cent (in absolute value) and is somewhat smaller than that found by others. This can be attributed to the fact that other studies typically measure growth over a much longer period – 25 to 30 years – compared to our period length of only 11 years.

[12] Barro (1991a,b) finds no effect of military spending on growth for a single cross-section of countries over the period 1960–85, while Barro and Sala-i-Martin (1995, Table 12-3) find no effect when the sample consists of two non-overlapping panels of ten years each for the period 1965–85. Knight *et al.* (1996) also find that the military spending ratio has an insignificant effect on growth in a cross-section over the 1971–85 period; however, the effect is significant and negative when they utilize a panel estimator applied to three non-overlapping five-year periods. These studies all include a separate dummy variable indicating whether a country participated in one or more wars over the sample period.

[13] Since the sample median of *thr* is 0, when evaluated at this value of *thr* the marginal effect of military spending on growth is also -0.56. When evaluated at the sample mean of *thr* (0.76), an increase in military spending reduces growth by $(0.56-0.16 \times 0.76=)$ 0.44 of a percentage point.

[14] Note that the negative direct effect of *thr* on growth implies that greater threat levels do not necessarily lead to an overall rise in growth.

[15] The residual is calculated from the regression that contains all of the variables, including *mil*, *thr*, and *mil* × *thr*. But the contribution from military spending is left out when computing the unexplained part of *gy* plotted on the vertical axis in the scatter diagram. Constructing residual growth in this manner implicitly evaluates the marginal effect of military spending by assuming each country faces no external threat. (The residuals are normalized to have a mean of 0.)

[16] This form allows a tractable solution. Our analysis applies for other functional forms, including a logistic specification. See Hirshleifer (1995), Skaperdas (1996), and Epstein (1997) for models of military conflicts illustrating the importance of considering relative military efforts among rivals in modeling and determining conflict outcomes.

[17] This suggests that the external threat level may be proxied by the level of foreign military expenditures, rather than the incidences of conflict between the domestic country and its foreign rivals, as in our empirical analysis in the second section.

[18] Note that the share of military spending out of total government expenditures is $g_m/(g_m+g)=\phi/(1+\phi)$; the military spending-to-output ratio is $g_m/y=\phi\tau/(1+\phi)$. Also note that, although $g_m/(g_m+g)$ and g_m/y are bounded by 1, ϕ is not.

[19] See the mathematical appendix for the derivation. These results were obtained by solving simultaneously the first-order conditions associated with the problem of $\max_{\phi\tau}[\gamma]$. This maximization is subject to the constraints imposed by equations (3)–(5), applying the implicit function theorem. We assume that the magnitude of the productivity coefficient and

the rate of time preference meet the conditions leading to positive endogenous growth. See Barro (1990) and Barro and Sala-i-Martin (1995) for further details.

20 With optimally set tax and expenditure rates, it is straightforward to show that $g/y = \alpha$ and $g_m/y = \alpha\tilde{\phi}$.

21 Figure 3 is calibrated by assuming $A = 1$, $\alpha = 0.2$, and t_c set equal to 0.1 or 0.2.

22 Figure 5 is calibrated by assuming $\alpha = 0.2$, $t_c = 0.1$, $\sigma = 1$, $\rho = 0.02$, $z/k = 0.0001$ (for the solid line), $z/k = 0.001$ (for the dashed line), and parametrically varying A to determine $\tilde{\phi}$and $\tilde{\gamma}$. See the Appendix.

23 See Gupta *et al.* (2000) for evidence that corruption raises military spending with a panel data set covering the period 1985–98.

24 The BI index ranges from 0 to 10, while the ICRG index ranges from 1 to 6. Tanzi and Davoodi splice the two series together to form a single 0–10 index for 1980 to 1995. The Tanzi–Davoodi measure refers specifically to the extent of bribes and other illegal payments demanded by government officials in business dealings and other transactions. The ICRG also collects data on a number of other measures of institutional quality, including maintenance of the rule of law, quality of the bureaucracy, risk of expropriation, and risk of repudiation of government contracts.

25 Our results below are unaffected if we define *goodgov* as the level of corruption for 1989, the initial year of our sample.

26 The observations are conditioned on data availability for all of the variables in the estimated growth equation reported in Table 3 below.

27 Since the standard deviation of the *goodgov* variable is 2.31, a one standard deviation improvement would imply growth falls by 0.22 of a percentage point.

28 Tanzi and Davoodi (1997, 2000) find indirect evidence that corruption decreases growth by reducing government revenue and the productivity of public investment. Barro and Sala-i-Martin (1995), find that the ICRG's 'rule of law' measure of institutional quality has a positive effect on growth.

29 The coefficients on *mil* and *mil* × *goodgov* imply that for index levels of good government above 6.35 (=1.27/0.20), (on a scale of 0–10) greater military spending has a positive effect on growth.

30 The data was obtained from the site http://www.worldbank.org/wbi/governance/govdata/index.html.

31 This is not surprising as the correlation of the *goodgov* and *governance* variables is 0.84. The correlation of *goodgov* and the various subindices of *governance* range from 0.64 to 0.85.

32 This marginal effect is calculated conditional on a country having the highest level of corruption, i.e. $goodgov = 0$. When evaluated at the sample median of *goodgov* (5.36), an increase in military spending reduces growth by only $(-1.27 + 0.20 \times 5.36 =)\ -0.20$ of a percentage point. When evaluated at the sample mean of *goodgov* (6.00), an increase in military spending reduces growth by $(-1.27 + 0.20 \times 6.0 =)\ -0.07$.

33 The results are not affected if a dummy variable for sub-Saharan African countries is included.

34 See Hewitt (1992) and Davoodi *et al.* (2001) for analyses of the association of military spending and non-military government spending.

35 See van Wijnbergen (1984) for a model of the 'Dutch Disease.'

36 Specifically,

$$\frac{\partial\tilde{\gamma}}{\partial\tilde{\phi}} = -\psi(1-\alpha\tilde{\phi})^{\frac{\alpha}{1-\alpha}}\{(1-\alpha)[1-\alpha\tilde{\phi}] + [1-\alpha(1+\tilde{\phi})]\} < 0$$

$$\frac{\partial^2\tilde{\gamma}}{\partial\tilde{\phi}\partial z} = \alpha\psi(1-\alpha\tilde{\phi})^{\frac{\alpha}{1-\alpha}}\left[\frac{\alpha[-\alpha(1+\tilde{\phi})]}{(1-\alpha)(1-\alpha\tilde{\phi})} + 2\right]\frac{\partial\tilde{\phi}}{\partial z} > 0$$

where $\psi \equiv \frac{A^{1/(1-\alpha)}[(1-t_c)\alpha]^{\alpha/(1-\alpha)}\alpha}{\sigma}$ and $\frac{\partial\tilde{\phi}}{\partial z} > 0$.

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Mathematical Appendix

The purpose of this Appendix is to derive equations (8a) and (8b) and characterize the properties of the determinants of the optimal tax, spending, and growth rates. Note first that equations (3)–(5) define output as an implicit function of the tax rate, τ, and military spending ratio, ϕ:

$$y = y(\tau, \phi) \tag{A1}$$

From equations (1) and (7) it follows that the optimization problem may be expressed as

$$\max_{\{\tau,\phi\}} \gamma = \max_{\{\tau,\phi\}} \left[(1-\tau) \frac{\partial y}{\partial k} \right] = \max_{\{\tau,\phi\}} \left[(1-\tau) \frac{y(1-\alpha)}{k} \right] \tag{A2}$$

The corresponding first-order conditions are:

$$\frac{\mathrm{d}y}{\mathrm{d}\phi} = 0; \qquad y = (1-\tau)\frac{\mathrm{d}y}{\mathrm{d}\tau} \tag{A3}$$

where $\frac{\mathrm{d}y}{\mathrm{d}\phi}$; $\frac{\mathrm{d}y}{\mathrm{d}\tau}$ are obtained from equation (A1). Applying equations (3)–(5) and the implicit function theorem, we find that

$$\frac{\mathrm{d}y}{\mathrm{d}\phi} = 0 \Leftrightarrow \frac{\alpha y}{1+\phi} - \frac{y}{\phi(1+\phi)} \, \frac{z}{g_m(1-t_c)+z} = 0 \tag{A4}$$

from which we infer that, for the optimal tax rate,

$$\alpha\tilde{\phi} = 1 - f \tag{A5}$$

Applying the implicit function theorem and equations (3)–(5) and collecting terms, we also find that

$$\frac{\mathrm{d}y}{\mathrm{d}\tau} = \frac{y}{\tau} \, \frac{\alpha + \frac{z}{g_m(1-t_c)+z}}{1 - \left[\alpha + \frac{z}{g_m(1-t_c)+z}\right]}. \tag{A6}$$

From substitution of equation (A6) into equation (A3) we infer that the FOC determining $\tilde{\tau}$ is

$$y = (1-\tilde{\tau})\frac{y}{\tilde{\tau}} \, \frac{\alpha + \frac{z}{g_m(1-t_c)+z}}{1 - \left[\alpha + \frac{z}{g_m(1-t_c)+z}\right]} \tag{A7}$$

Combining equations (A5) and (A7) we find that

$$\tilde{\tau} = \alpha(1+\tilde{\phi}) \tag{8a}$$

To obtain a reduced-form solution for ϕ, we next substitute out for g in equation (3) with equations (4) and (5) as well as out for f with equation (A5), and derive

$$\tilde{y} = A^{1/(1-\alpha)} k[(1-t_c)\alpha]^{\alpha/(1-\alpha)}(1-\alpha\tilde{\phi})^{1/(1-\alpha)} \tag{A8}$$

Applying equations (4) and (5) to equation (A5) gives equation (11)

$$\alpha\tilde{\phi} = \frac{z}{\frac{\tilde{\phi}(1-t_c)\tilde{\tau}\tilde{y}}{1+\tilde{\phi}} + z} \tag{11}$$

Substituting for $\tilde{y}$ in equation (11) with equation (A8) and for $\tilde{\tau}$ with equation (8a) gives equation (8b), a condition that defines $\tilde{\phi}$ implicitly:

$$(\tilde{\phi})^2 \alpha[\alpha(1-t_c)]^{\frac{1}{1-\alpha}}[1-\alpha\tilde{\phi}]^{\frac{\alpha}{1-\alpha}} A^{\frac{1}{1-\alpha}} = \frac{z}{k} \tag{8b}$$

To establish the properties of the determinants of optimal tax and growth rates, we logarithmically differentiate equation (8b) and use equation (8a) to obtain

$$\frac{2(1-\tilde{\tau}) + \alpha^2\tilde{\phi}}{\tilde{\phi}(1-\alpha\tilde{\phi})(1-\alpha)}\ \mathrm{d}\tilde{\phi} = \mathrm{d}\log\frac{z}{k} - \frac{1}{1-\alpha}\mathrm{d}\log A - \frac{1}{1-\alpha}\mathrm{d}\log(1-t_c) \tag{A9}$$

Equations (11) and (8a) then imply that

$$\tilde{\phi} = \tilde{\phi}(z, t_c, A); \quad \tilde{\phi}_z > 0, \ \ \tilde{\phi}_{t_c} > 0, \ \ \tilde{\phi}_A < 0.$$

$$\tilde{\tau} = \tilde{\tau}(z, t_c, A); \quad \tilde{\tau}_z > 0, \ \ \tilde{\tau}_{t_c} > 0, \ \ \tilde{\tau}_A < 0.$$

To determine the optimal growth rate $\tilde{\gamma}$, note that $\frac{\partial y}{\partial k} = \frac{y(1-\alpha)}{k}$ and equation (7) imply

$$\tilde{\gamma} = \frac{1}{\sigma}\left[(1-\tilde{\tau})\frac{\tilde{y}(1-\alpha)}{k} - \rho\right]$$

Substituting for $\tilde{y}$ with equation (A8) and for $\tilde{\tau}$ with equation (8a) gives

$$\tilde{\gamma} = \frac{1}{\sigma}\left[A^{1/(1-\alpha)}[(1-t_c)\alpha]^{\alpha/(1-\alpha)}(1-\alpha)[1-\alpha(1+\tilde{\phi})](1-\alpha\tilde{\phi})^{1/(1-\alpha)} - \rho\right] \tag{A10}$$

Recalling equation (8a), $1 - \alpha\ (1 + \tilde{\phi}) = 1 - \tilde{\tau} > 0$. Applying this relation to equation (A10), it follows that[36]

$$\frac{\partial\tilde{\gamma}}{\partial\tilde{\phi}} < 0, \qquad \frac{\partial^2\tilde{\gamma}}{\partial\tilde{\phi}\partial z} > 0$$

and

$$\tilde{\gamma} = \tilde{\gamma}(z, t_c, A); \quad \tilde{\gamma}_z < 0, \ \ \tilde{\gamma}_{t_c} < 0, \ \ \tilde{\gamma}_A > 0. \qquad \text{(A11)}$$

Table A1. Determinants of Growth, Military Spending and Governance

	(1)	*(2)*	*(3)*
mil		−0.04	−0.08
		(0.13)	(0.12)
		(0.15)	(0.15)
governance	1.88	1.82	0.22
	(0.45)***	(0.46)***	(0.64)
	(0.63)***	(0.62)***	(0.75)
mil × *governance*			0.48
			(0.14)***
			(0.21)**
lgdp	−2.52	−2.47	−2.35
	(0.41)***	(0.42)***	(0.40)***
	(0.38)***	(0.38)***	(0.33)***
leduc	0.18	0.19	0.29
	(0.37)	(0.38)	(0.36)
	(0.31)	(0.31)	(0.30)
gpop	−0.67	−0.61	−0.88
	(0.31)**	(0.35)*	(0.34)***
	(0.36)*	(0.35)*	(0.35)**
inv/gdp	0.05	0.05	0.05
	(0.04)	(0.04)	(0.04)
	(0.03)	(0.03)	(0.03)*
Africa	−2.98	−2.96	−2.59
	(0.60)***	(0.61)***	(0.58)***
	(0.81)***	(0.82)***	(0.74)***
constant	22.73	22.21	21.88
	(3.40)***	(3.50)***	(3.30)***
	(3.42)***	(3.42)***	(2.95)***
# of cos.	93	91	91
Adj R2	0.46	0.44	0.51

Notes: Estimation by OLS. Standard errors in parentheses; robust standard errors in brackets. ***indicates significance at 1%, **at 5%, *at 10%. Dependent variable is *gy*, the annual average real per capita GDP growth over 1989-98. Explanatory variables include *mil*, military spending/GDP; *governance*, the Kaufmann, Kraay, and Zoido-Loboton measure of governance quality (higher values denote less corruption and better government); *mil* × *governance*, an interaction of the two variables; *lgdp*, log of initial real per capita GDP; *leduc*, log of initial years of male schooling; *gpop*, population growth rate; *inv/gdp*, the investment/GDP ratio; and *Africa*, dummy for sub-Saharan African countries.

Data Appendix. Countries in regression samples

Country Name	*Code*	*Missing Corruption Data (*)*
Algeria	DZA	
Argentina	ARG	
Australia	AUS	
Austria	AUT	
Bangladesh	BGD	
Barbados	BRB	*
Belgium	BEL	
Benin	BEN	*
Bolivia	BOL	
Botswana	BWA	
Brazil	BRA	
Cameroon	CMR	
Canada	CAN	
Central African Republic	CAF	*
Chile	CHL	
China	CHN	
Colombia	COL	
Congo, Dem. Rep.	ZAR	
Congo, Rep.	COG	
Costa Rica	CRI	
Cyprus	CYP	
Denmark	DNK	
Dominican Republic	DOM	
Ecuador	ECU	
Egypt, Arab Rep.	EGY	
El Salvador	SLV	
Fiji	FJI	*
Finland	FIN	
France	FRA	
Gambia, The	GMB	
Germany	DEU	
Ghana	GHA	
Greece	GRC	
Guatemala	GTM	
Guyana	GUY	
Haiti	HTI	
Honduras	HND	
Iceland	ISL	
India	IND	
Indonesia	IDN	
Iran, Islamic Rep.	IRN	
Ireland	IRL	
Israel	ISR	
Italy	ITA	
Jamaica	JAM	
Jordan	JOR	
Kenya	KEN	
Korea, Rep.	KOR	
Lesotho	LSO	*
Malawi	MWI	
Malaysia	MYS	
Mali	MLI	
Mauritius	MUS	*
Mexico	MEX	

(*continued*)

Data Appendix. (*Continued*)

Country Name	*Code*	*Missing Corruption Data (*)*
Mozambique	MOZ	
Nepal	NPL	*
Netherlands	NLD	
New Zealand	NSZ	
Nicaragua	NIC	*
Niger	NER	
Norway	NOR	
Pakistan	PAK	
Panama	PAN	*
Papua New Guinea	PNG	
Paraguay	PRY	
Peru	PER	
Philippines	PHL	
Portugal	PRT	
Rwanda	RWA	*
Senegal	SEN	
Sierra Leone	SLE	
Singapore	SGP	
South Africa	ZAF	
Spain	ESP	
Sri Lanka	LKA	
Sweden	SWE	
Switzerland	CHE	
Syrian Arab Republic	SYR	
Thailand	THA	
Togo	TGO	
Trinidad and Tobago	TTO	
Tunisia	TUN	
Turkey	TUR	
Uganda	UGA	
United Kingdom	GBR	
United States	USA	
Uruguay	URY	
Venezuela	VEN	
Zambia	ZMB	
Zimbabwe	ZWE	

Note: Countries included in regressions in Table 2. Countries with missing data on *goodgov* and that are omitted from the results reported in Table 3 are denoted in the last column.