Journal of Applied Economics, Vol. IV, No. 2 (Nov 2001), 329-360

SIZE OF THE MILITARY SECTOR AND ECONOMIC GROWTH: A PANEL DATA ANALYSIS OF AFRICA AND LATIN AMERICA

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We estimate the influence of defense spending and military labor use on economic growth in African and Latin American countries. Our model integrates disparate implications from the defense economics literature into a Barro-style model of economic growth that controls for political and economic institutional variation across countries. Our panel data analysis of 44 countries in Africa and Latin America from 1975 to 1989 also controls for cross-country variation in lost human capital and public sector production inefficiencies. We find empirical evidence that the defense burden on economic growth is non-linear, with low levels of military spending increasing economic growth but higher levels of military spending decreasing growth. We also find evidence that the influence of military labor use on growth is non-linear, and exhibits a greater drag on economic growth in those countries with relatively higher levels of adult male education attainment.

JEL classification codes: H5, O4

Key words: defense burden, economic growth

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I. Introduction

Capturing the impact of military spending on economic growth in developing countries has been an elusive problem for defense economists and has not been fully investigated by development economists. A review article by Deger and Sen (1995) notes that the *Handbook of Developmental Economics* rarely mentions the role of military spending in economic development. Ram's (1995) comprehensive review of empirical studies in the defense economics literature reveals conflicting empirical implications arising from disparate attempts at quantifying the defense burden on economic growth. He notes that a lack of consensus among both theoretical and empirical studies regarding the proper model specification has led to this diverse array of empirical results.

In this paper, we integrate implications stemming from many competing defense burden models gleaned from the defense economics literature into a simple growth specification. Our model allows various avenues for the defense burden on economic growth to be revealed empirically. Using panel data from African and Latin American countries over the period of 1975 to 1989 we find empirical evidence that the defense burden in these countries has a non-linear influence on economic growth, changing from positive to negative as military spending represents an ever-higher proportion of GNP. We also find that the influence of military labor use on growth is similarly non-linear and depends upon the level of male educational attainment in a country. These empirical results were obtained while controlling for cross-country variation in certain political and economic institutional characteristics.

The framework for our model is developed by modifying a specification designed by Robert Barro (1991), and further extended in Barro and Sala-i-Martin (1995) and Barro (1997).[1] We are compelled to use Barro's neoclassical model of economic growth as a starting point because his growth specification includes variables designed to control for differences in institutional influences

[1] Unless otherwise noted, all further references to Barro pertain to his 1997 study.

across countries. The theoretical consideration of the influence of institutional structure and public policy on economic growth has been explored by notable political economists such as Friedman (1962), Olson (1982), and North (1990), among others.

More recently, empirical work by Dawson (1998) examines a set of economic freedom indexes for countries worldwide that have been developed by Gwartney, Lawson and Block (1995) and the relative level of political freedoms developed by Gastil (1987). These indexes are aggregations of various measures reflecting cross-country variation in the level of institutional arrangements that directly affect the economic and political freedoms, respectively, enjoyed by the citizens of each country. Dawson finds robust empirical support that the aggregated economic indexes, but not the political indexes, successfully explained a significant amount of the variation in economic growth across countries. Gastil (1987) generates indexes measuring relative levels of political freedoms across countries and found evidence that greater levels of such freedoms promote economic prosperity. However, few empirical studies of institutional influences on economic growth specifically address how a nation's military sector—which we feel is an important institutional influence on the national economy—can affect growth.

For example, Barro's specification controls for variation in the size of central government as an explanatory variable for growth. The particular variable he chooses for central government spending does not include education and military expenditures. Barro's intention is to include an explanatory variable that reflects total central government expenditures, but removes from those expenditures any funds used for producing services that are often considered "public goods" in an economics sense. The remaining expenditures are intended to proxy the extent to which the central government wastes productive resources via economically inefficient policies and institutional arrangements that hinder economic growth.[2] Yet, Barrow's

[2] Studies by Scully (1989) and Gwartney, Holcombe, and Lawson (1998) find empirical evidence that countries with larger central governments relative to their GNP do tend to grow more slowly than those countries with relatively smaller government sectors.

removal of military spending from total central government expenditures in this manner also creates an interesting opportunity for isolating the impact that military displacement of productive resources might have on a nation's rate of economic growth. Quantifying the extent of the defense burden on national economic growth in Africa and Latin America is the very question we pursue in the following empirical investigation.

The next section is a brief review of previous theoretical and empirical work within the defense economics literature regarding the relationship between military sector resource use and national economic growth. Several theories are examined regarding the direct and indirect influences that military spending and labor use might have on growth. We propose a simple model that integrates many of the different implications stemming from these various perspectives of the defense burden on growth and we motivate how military resource use is likely to have a non-linear influence on economic growth.

The third section introduces our augmented specification of Barro's neoclassical growth model. We attempt to quantify how defense spending and military use of labor influences economic growth using panel data analysis. The defense burden on growth is measured by military spending relative to the size of the national economy as well as by the proportion of the total population actively participating in the military sector.

The fourth section reviews our panel data analysis results, derived from 44 countries in Africa and Latin America over three consecutive, five-year growth periods from 1975 to 1989. We find evidence that the defense burden on economic growth in these developing countries is non-linear. When the size of the military sector in a country is relatively small relative to the economy, defense spending seems to have a positive but diminishing influence on economic growth. However, this influence soon turns negative as defense spending represents a higher proportion of the country's economy. We also find that military use of labor is non-linear. While military labor use may have a positive influence on economic growth at low levels of labor force participation, this influence would eventually turn negative at higher levels of labor force use. We also find that any positive influence arising out of military use of labor diminishes significantly as the level of male educational attainment in a country increases.

Lastly, we explore the robustness of the panel data results. It appears that the longitudinal dimension of the panel data, rather than the cross-sectional dimension, exerts the stronger influence over our empirical results. Our analysis also indicates that there is little statistical support for considering the data from the African and Latin American regions separately.

II. Describing the Impact of Defense on Economic Growth

Deger and Sen (1995) and Ram (1995) provide comprehensive theoretical and empirical reviews, respectively, of the defense economics literature as it relates to analyzing the defense burden on economic growth. Interest in this area of research was initially motivated by Benoit's (1973) unexpected empirical finding that military spending appeared to increase economic growth in many developing countries. Ram summarizes how subsequent empirical investigations into this issue have produced wide-ranging statistical results, most of which could not duplicate Benoit's findings.

Deger and Sen attribute this empirical inconsistency across studies to the lack of consensus among authors as to the proper theoretical avenue of how military spending influences economic growth. As a result, empirical specifications tend to be narrow in scope in an attempt to measure a specific channel of influence, thereby causing the model specifications to vary widely across different studies. Additionally, the analysis is often conducted using data sets within narrow time frames and/or small cross sections of data. Deger and Sen conclude that any meta-analysis of these many empirical implications would be a formidable challenge, yet they attempt to collect what could loosely be termed a "consensus view" of the many potential influences that military resource use may have on a nation's economic growth. They also make some specific suggestions for further refinement of research efforts in this area.

A. Theoretical Issues in the Defense Burden Literature

With respect to the theoretical treatment of the defense burden issue, Deger and Sen summarize the direct opportunity costs to economic activity from military resource use that have appeared in previous studies. This list includes lower levels of private sector investment and domestic savings, diminished domestic consumption due to lower aggregate demand, and a smaller tax base available for providing needed civilian, public sector services—each of which is expected to directly and negatively influence economic growth. They also note that many studies describe various indirect costs that military resource use might have on growth. For example, the private sector business investment may be crowded out due to higher prevailing interest rates in the economy when the military sector is financed primarily through deficit spending. Domestic savings may further decline from the loss of public sector services or transfer payments that must compete with the military for tax revenues. The increased displacement of a well-educated workforce into military service also deprives the civilian sector of the use of labor and its human capital, further decreasing economic growth. Therefore, if one assumes that declining marginal productivity prevails in the civilian sector of a nation's economy, then the magnitude of these direct and indirect opportunity costs to economic growth should increase at an increasing rate as the military sector uses a greater portion of a nation's available productive resources.

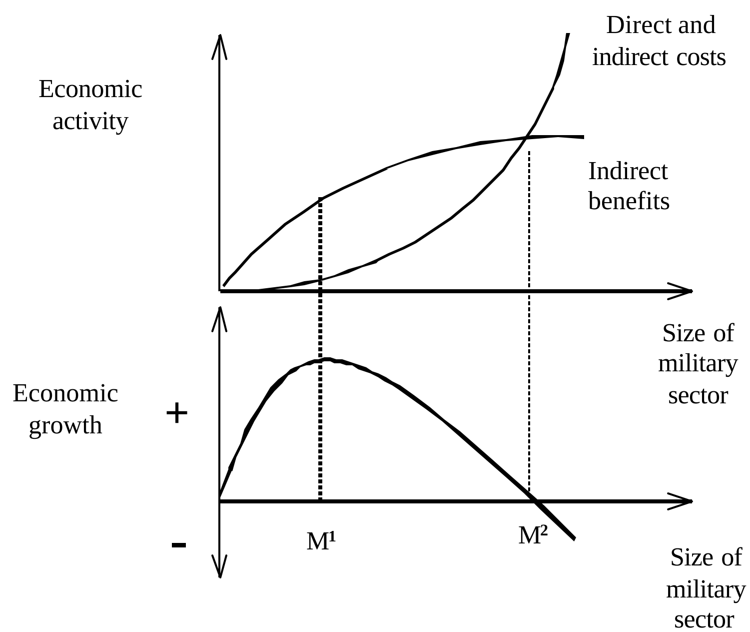
Yet, there remains the possibility that the military sector may have some positive, indirect effects on economic growth as well. Deger and Sen note that various studies have considered whether technology spin-offs arising from defense weapons production in countries with capital intensive military sectors might enhance growth. Additionally, innovations in management and logistics within large scale supply and support operations can be experienced by economies that boast a larger military sector. These innovations could be carried over to the private or civilian public sectors, enhancing civilian sector production and distribution efficiency, and positively influence the rate of economic growth in that country.

With respect to public sector productivity, many developing countries use military labor to build public infrastructure projects or provide services (highways, police services, and water projects) that are not considered typical military sector activities in developed countries. From a human capital standpoint, a relatively uneducated and disenfranchised young male workforce could benefit from a brief stint serving in military service if such training afforded opportunities for learning self-discipline, problem solving techniques and effective communication skills that are otherwise not available to them in the civilian sector. Therefore, if one assumes that diminishing marginal productivity prevails in the military sector of the economy as well, then the magnitude of these benefits to economic growth would increase at a decreasing rate (and, perhaps, eventually turn negative) as the military sector uses a greater portion of a nation's available productive resources.

The underlying model of this paper is the result of an effort to unify these many disparate concepts of how military spending can influence economic growth, and to do so in the most robust way possible. Figure 1, below, illustrates how military resource use is theorized to influence the growth rate of a nation's economy when assuming diminishing returns to all sectors of the economy. As the proportion of a country's productive resources diverted to the military sector increases, the total direct and indirect opportunity costs (lost economic growth) in the civilian sector will increase at an increasing rate. However, the total indirect benefits (additional economic growth) arising from military use of those resources will simultaneously increase at a decreasing rate. Summing these two functions to find the net influence of military resource use on economic growth reveals a non-linear, concave defense burden function describing the relationship between the size of the military sector and economic growth in the national economy.

This simple model of the defense burden on economic growth implies that when the military sector is very small relative to the entire economy, the net effect on economic growth may be positive. As more of a country's resources are diverted to military use, this positive influence on economic growth reaches some maximum influence at point M_1. The net positive

Figure 1. The Defense Burden Function



influence on growth then declines as military spending continues to expand, eventually turning negative after point M_2. We use panel data from Latin American and African countries in an attempt to empirically estimate the specific shape of this defense burden function with respect to both military spending and labor use.

B. Empirical Issues in the Defense Burden Literature

With respect to the empirical studies, Ram performs a comprehensive review of the defense economics literature and makes many general recommendations for future research in quantifying the influence of military resource use on economic growth. For instance, he notes that most studies focus on military spending while few studies address the specific opportunity cost to the civilian sector of the economy when labor and it's inherent human capital are diverted into military service. Ram also encourages testing the sensitivity of any empirical results across different time periods and geographic samples to verify the robustness of any theoretical postulates. He further suggests using at least five-year long growth periods to better capture the total influence that increased military resource use might have on economic growth. Our objective in the following empirical analysis is to satisfy these concerns regarding empirical research into the effects of the defense burden on economic growth in the countries of Latin America and Africa.

III. Modifying the Barro Model to Reflect the Impact of Defense on Growth

The dependent variable of our growth model specification is defined as the annual rate of growth in real, per-capita GDP (measured in decimal form) averaged over a five-year period. The economic growth and explanatory variables common to the Barro model come directly from the Barro-Lee database.[3] Data on defense spending (as a percent of GNP) and military personnel (as a percent of the population) are taken from the annual report World Military Expenditures and Arms Transfers, published annually by the U. S. Arms Control and Disarmament Agency (various years).

The value of each explanatory variable in our specification represents the data at the initial year of each five-year growth period of the dependent variable, or represents data that is a calculated average over the five-year period prior to the growth period of the dependent variable. This helps control for the potential of reverse causality, such as economic growth causing greater military spending. Data reflecting the three time periods of 1975-1979, 1980-1984, and 1985-1989 are analyzed for a sample of 44 African and Latin American countries. A list of the countries used in our analysis appears in the Appendix

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[3] These data are available at http://www.nuff.ox.ac.uk/Economics/Growth/barlee.htm.

and includes all countries for which data were available for each explanatory variable used in our specification.

A. Using the Barro Model of Economic Growth as a Foundation

Our growth model specification starts with the basic components of Barro's neoclassical growth model as explanatory variables. The initial level of real, per-capita GDP (GDP) is included in log form to capture the empirically observed income-convergence effect on growth, where poorer countries tend to grow faster than richer countries. The average number of years of adult male educational attainment (EDUC) and the average years of life expectancy (LIFE) are both included in log form as proxy measures for the level of human capital in the labor force in each country. The log of the fertility rate (FERT) is also included as a proxy measure for the growth rate of the labor force in a country. Barro included this variable to reflect the negative impact on growth that arises from a low capital-to-labor ratio associated with those countries experiencing over-population pressures.

Barro included variables designed to capture the influence of economic and political institutions on economic growth, and we include similar variables to control for these influences as well. The explanatory variable GOV represents central government expenditures, less education and military expenditures, expressed as a ratio of GDP and enters the specification in log form. Barro's intent was to eliminate those public expenditures in central government spending that are being used for providing "public goods" in the economic sense. The remaining expenditures captured by GOV proxy the potential for governments to use available resources for enacting economically unproductive public sector policies.

Barro also included a democracy index developed by Gastil (1987). This qualitative ranking reflects the ability of a country's citizens to influence outcomes through direct political participation, and is measured as an index on a scale ranging from 1 to 7 (with 1 being the most democratic country ranking possible). Barro includes this index as an explanatory variable in quadratic form in order to capture the non-linear influence of democratic freedoms on growth. He theorizes that when democratic freedoms in a country are very low, any increase in these freedoms would help citizens constrain government leaders' ability to amass personal wealth through unpopular and unproductive public policies favoring those in power. However, after some level of democratic freedom is achieved, Barro surmises that further increases in such democratic freedoms would allow for substantial income or wealth redistribution policies to be implemented by the majority at the expense of the minority. He notes that such redistribution efforts—usually under the guise of taking resources away from the rich to subsidize the poor, such as land reform measures—can have a stifling effect on economic activity and growth. Barro's empirical investigation included developed nations as well as developing nations. Since developed countries have higher levels of democratic freedoms than most developing countries, and since our investigation is limited to the developing countries of Latin America and Africa, we include this democracy index (DEMOC) as an explanatory variable only in linear form.[4]

We also include private investment as a ratio of GDP in log form (INV) in deference to existing empirical models used in the defense economics and development economics literature. Barro's specification did not include private investment in his specification since his empirical analysis indicated that such investment may be endogenously determined by the level of economic growth rather than growth being determined by investment. Since the omission of investment in his model contrasts with most other empirical models of economic growth, including most of those models found within the defense economics literature, we include it in our specification. However, the empirical results for all of the other variables in our specification were not sensitive to the inclusion of this explanatory variable.

Barro's empirical analysis confirmed Okun's (1971) findings that price inflation is associated with increased price level variability over time, and

[4] Our empirical analysis did not statistically support a quadratic form for DEMOC.

that both of these characteristics were found to hinder economic growth independently. In order to control for cross-country variation in institutional monetary policies that exacerbate inflation, our specification includes the annual growth rate of the M1 money supply less the rate of growth in potential GDP, as averaged over the proceeding five-year period of growth (M1GROW).[5] In this way, the explanatory variable is not reflecting the variability of price inflation, but rather reflects evidence of poor policies that may cause inflation.

Barro's analysis also confirmed that variation in inflation from year to year diminished economic growth in a non-linear way. In light of this, our specification includes the standard deviation for annual inflation over the previous five years (INFL),[6] as well as its squared value (INFLSQR), to account for any non-linearity of this influence on growth.

B. Adding the Military Sector into our Specification

We now address the issue of including the effects of military resource use on economic growth in our specification. Military expenditures expressed as a percent of GNP (MS) in the initial year of each growth period is used as an explanatory variable to capture the influence on economic growth from military spending. However, as Figure 1 illustrates, the positive effects on economic growth arising from increased military spending would eventually be dominated by the opportunity costs of diverting resources away from the civilian sector of the economy, potentially turning the net effect of military spending on growth from positive to negative.[7] Therefore, we use a quadratic

[5] This measure is calculated by Gwartney, Lawson and Block (1995) and is used as an indicator of institutional economic policy when calculating their aggregated economic freedom indexes.

[6] This variable is also taken from Gwartney, Lawson and Block (1995).

[7] Empirical support for a non-linear relationship between military resource use and growth can also be found in Frederiksen and Looney (1995). Dividing a small sample of developing

functional form and include the squared value of MS (MSSQR) in our specification as well.

Landau (1994) theorized that if public sector decision-makers perceive an increase in the threat to national security arising from a military build-up in a neighboring country, these decision makers may also have a heightened awareness of the increased opportunity cost of maintaining any unproductive government policies. Policy makers in such a scenario would have greater appreciation for how self-serving economic policies shrink the potential tax base from which they desire to fund an increase in military capacity, such that more economically efficient public sector policies may be implemented while the government simultaneously increases defense spending. In light of this, Landau found empirical support for the idea that heightened perceptions of external security threats motivated more productive uses of available resources in the civilian, public sector. The resulting increase in economic growth was observed despite the simultaneous increases in defense spending, illustrating the complex nature of interpreting the empirical statistical correlation between military spending and economic growth.

In our specification, we assume that heightened perceptions of national security threats could stem from either external or internal sources, such as the threat of a pending domestic revolutionary movement. Therefore, we assume that a heightened perception of either internal or external threats is ultimately exhibited by a relative higher level of defense spending as a ratio of GNP. In light of this, the product of GOV (which excludes defense and education spending) and MS creates the explanatory variable MSGOV, and is included in our specification. The coefficient estimate for MSGOV can then be interpreted as capturing the added productivity (or the diminished inefficiency) of civilian, public sector resource use that occurs when higher

countries into two sub-groups—one with high capitalization economies and one with low capitalization economies—they found that the difference in the influence exerted by military resource use on growth across the two groups was statistically significant at conventional levels of confidence.

levels of military spending occur simultaneously with higher levels of civilian government spending.

Finally, we turn toward the military use of the labor force. The percent of a nation's population devoted to the military sector (MP) is also included as an explanatory variable in our model specification.[8] As Figure 1 illustrates, the net influence of increasing military use of resources on economic growth is presumed to be non-linear, and we therefore include the squared value of MP (MPSQR). From a human capital perspective, displacing young men from the private sector workforce for military service (perhaps through conscription) when the average level of male educational attainment and human capital is relatively high would create a significant opportunity cost to the civilian economy and decrease economic growth.[9] Yet, if the average level of male educational attainment and human capital of the young male workforce is relatively low, then military training may create a net positive influence on economic growth when an economy gains enduring human capital at the temporary expense of lost labor resources (Blomberg, 1997). In this light we include the product of MP and EDUC (MPEDUC) as an interaction variable. In this way, we use the level of EDUC to control for the degree of human capital lost to the civilian sector when a given amount of the labor force is used by the military sector. A negative coefficient on MPEDUC can be interpreted as measuring the extra opportunity cost to the civilian sector economy due to military displacement of human capital, which is in addition to the opportunity cost of displaced labor.

[8] Although one would expect that the portion of the population in the military and the level of military expenditures relative to GDP to be highly correlated, the correlation coefficient between MS and MP in our sample is only 0.59.

[9] A dummy variable for conscription (vice voluntary enlistment) was included for each country in all regression specifications and was found to be insignificant. Additionally, none of the remaining variables were found to be sensitive to the inclusion of this variable in any equation.

IV. The Empirical Evidence

In the Appendix, we present descriptive statistics for all the explanatory variables used in our specification (for the entire sample as well as for each of the two continental regions). Our sample is (roughly) divided evenly between the two continents, but many countries in Northern Africa are not represented due to lack of available data for some of the variables used in our specification. Thus, the empirical results interpreted below may be more applicable to countries in Sub-Saharan Africa rather than to all of Africa.

Table 1 shows the results of the panel data analysis for the set of 44 countries of Africa and Latin America. Three separate five-year growth intervals were used covering the period 1975-1989, for a total of 129 observations.[10] Recall that the dependent variable is the annual rate of growth in real GNP per-capita (in decimal form) averaged over each five-year period, and is explained by the 16 independent variables, as defined above. This fixed-effects approach includes time period and country-specific dummy variables, such that full advantage of the panel data can be realized while controlling for any heterogeneity in the longitudinal and/or cross-sectional dimension of the panel data. Additionally, a heteroskedasticity consistent matrix estimator of the covariance matrix, based on White (1980), is used to generate unbiased standard errors for inferencing procedures.

Our primary focus is on the first equation (EQ1) in Table 1. The adjusted R-squared statistic indicates that this specification explains about three fourths of the total variation in the dependant variable. All of the coefficient estimates from the economic, institutional and demographic variables that are common to Barro's (1997) growth model are of the expected sign, and all but one (LIFE) are found to be statistically significant at the traditional 5% level of confidence.[11]

[10] The panel is slightly unbalanced due to a single missing observation point for two separate nations in two different time periods.

[11] The positive and significant coefficient estimate on M1GROW suggests that an increase

Table 1. Panel Data Results for three Continuous Five-Year Periods for 44 Countries (Dependent Variable: Average Annual Change in Real Per-Capita GDP)

	EQ1	EQ2	EQ3
GDP	-0.1778 ***	-0.0112	-0.2038 ***
	(0.0178)	(0.0070)	(0.0226)
INV	0.0153 *	0.0154 **	0.0195 *
	(0.0093)	(0.0065)	(0.0110)
GOV	-0.0552 **	-0.0054	-0.0535 *
	(0.0232)	(0.0137)	(0.0315)
EDUC	0.1028 ***	0.0032	0.0715 **
	(0.0264)	(0.0089)	(0.0296)
LIFE	0.1156	-0.0123	-0.3059 **
	(0.1425)	(0.0461)	(0.1352)
FERT	-0.1276 ***	-0.0188	-0.0628 *
	(0.0335)	(0.0212)	(0.0368)
M1GROW	0.0004 ***	0.0003 **	0.0003 ***
	(0.0001)	(0.0001)	(0.0001)
INFL	-0.0002 ***	-0.0002 **	-0.0002 ***
	(3.3E-05)	(7.07E-05)	(3.92E-05)
INFLSQR	4.21E-08 ***	2.92E-08 **	3.32E-6 ***
	(6.4E-09)	(1.32E-09)	(7.35E-08)
MS	0.0360 ***	0.0185	0.0348 **
	(0.0117)	(0.0129)	(0.0165)
MSSQR	-0.0008 **	-0.0010 **	-0.0005
	(0.0004)	(0.0005)	(0.0005)
MSGOV	0.0198 ***	0.0094 *	0.0208 ***
	(0.0053)	(0.0057)	(0.0079)
MP	0.4651 ***	0.0813	0.3216 **
	(0.1187)	(0.0624)	(0.1480)

Table 1. (Continue) Panel Data Results for three Continuous Five-Year Periods for 44 Countries (Dependent Variable: Average Annual Change in Real Per-Capita GDP)

	EQ1	EQ2	EQ3
MPSQR	-0.1113 ***	0.0142	-0.1170 **
	(0.0400)	(0.0285)	(0.0551)
MPEDUC	-0.2581 ***	-0.0508 *	-0.1499 **
	(0.0630)	(0.0290)	(0.0744)
DEMOC	-0.0062 **	-0.0030	-0.0003
	(0.0027)	(0.0020)	(0.0029)
Time dummies?	Yes	Yes	No
Country dummies?	Yes	No	Yes
R Squared	0.88	0.40	0.82
Adj. R Squared	0.77	0.30	0.66
No. of obs.	129	129	129
Mean of dep. var.	0.0020	0.0020	0.0020

Notes: * = 10%, ** = 5%, and *** = 1% level, respectively. Standard error of the coefficient estimate appears in parenthesis.

A. Summarizing the Results of the Panel Data Analysis for the Military Variables

With respect to military spending, the positive and significant coefficient on MS and negative and significant coefficient on MSSQR supports our non-

in the growth of the money supply relative to real, potential GDP will improve economic growth *if* it does not increase price level variation (as controlled for by INFL). The net impact of price variation over time is found to be negative for the entire range of values of M1GROW and INFL in our sample.

linear model of the defense burden on economic growth. Low levels of military spending appear to generate a positive influence on economic growth despite the opportunity costs to the civilian economy associated with military spending, but higher levels of military spending appear to generate sufficient opportunity costs to eventually dominate any indirect benefits from military spending. (The net influence of military spending on growth for the average country in our panel data sample is quantified explicitly below.)

The net influence of government spending on growth also depends upon the interaction term of GOV with military spending (MSGOV). MSGOV generates a positive and significant coefficient estimate while GOV generates a negative and significant estimate. This implies that while the net effect of civilian government spending on growth is still negative (as calculated at the average level of military spending in our sample), the synergy between simultaneously high levels of civilian government spending and military spending tends to diminish the negative influence that a given amount of military spending has on economic growth. This empirical result supports Landau's conjecture that a heightened perception of military threat by the government can be statistically correlated with that government using civilian, public sector resources more efficiently via more efficient public policies enacted to retain the tax base necessary for military expansion.

With respect to military use of labor, the coefficient estimate on MP is positive and significant while MPSQR generates a negative coefficient (though significant only at the 10% level of confidence). This indicates that military use of labor seems to have a positive influence on growth at relatively low levels of labor participation in the military. The sign and magnitude of MPSQR indicates that this positive influence eventually turns negative as more labor is diverted to the military. (The net influence of military labor use on economic growth for the average country in our sample is quantified explicitly below.)

The negative and significant coefficient estimate on MPEDUC implies that when the military draws its labor from an better-educated male work force, any positive influence that such military labor use may have on a nation's economic growth is diminished. This dampening effect is due to the increased loss of human capital from the civilian sectors of the economy for a given amount of military labor use. The net effect of male educational attainment on economic growth is still positive when calculated at our sample's average level of military labor force participation.

B. Deriving the Marginal Impact of the Defense Burden Function

Due to the functional form of our growth model specification, which includes some multiplicative interaction terms among the explanatory variables, the net effects on economic growth of government spending, education, military spending or military labor participation are not inherently obvious. Therefore, Table 2 presents the ceteris paribus net impact that a one-unit increase in each explanatory variable is expected to have on annual economic growth, as calculated at the value of the sample mean for each related explanatory variable in our specification.

For example, if the dependent variable in our growth model is expressed as Y, taking the partial derivative of Y with respect to MS can approximate

Table 2. Net Impact on Growth, as Evaluated at the Sample Mean

	Net Effect	F-Value
GOV	-.0041 [a]	5.80 ***
EDUC	.0171 [b]	14.93 ***
INFL	-.00023 [c]	30.02 ***
MS	-.0032 [d]	4.01 ***
MP	.0943 [e]	7.33 ***

Notes: All estimates are based on EQ1 in Table 1; [a] evaluated at mean value of MS (2.58) [b] evaluated at mean value of MP (0.332); [c] evaluated at mean value of INFL (81.54); [d] evaluated at mean value of MS (2.58) and GOV (-1.77); [e] evaluated at mean value of MP (0.332) and EDUC (1.15); *** = 1% level.

the marginal impact of a change in military spending on annual growth. The result is illustrated by Equation (1) below:

$$\delta Y/\delta MS = \beta_{MS} + (2\ \beta_{MSSQR}\ MS) + (\beta_{MSGOV}\ GOV) \quad (1)$$

Using this equation, we can now calculate the average affect of a one-percentage point increase in military spending on annual economic growth. Inserting the sample means of military spending for the variable MS (2.52% of GNP) and central government spending for the variable GOV (17% of GNP, entered in log form) into Equation (1) reveals that the net impact of a one percentage point increase in military spending results in a 0.32% decline in annual growth. This may seem a rather small reduction, but it should be compared to the annual growth rate in our panel data sample of only 0.2% per year. However, if we insert the level of military spending at the sample average plus one sample standard deviation (4.55% of GNP), then the negative impact of a one percentage point increase in military spending becomes a substantial 7.2% reduction in average annual economic growth.

Proceeding as above, the partial derivative of the dependent variable Y with respect to MP can be expressed by Equation (2) below:

$$\delta Y/\delta Mp = \beta_{MP} + (2\ \beta_{MPSQR}\ MP) + (\beta_{MPEDUC}\ EDUC) \quad (2)$$

Using this equation, we can now calculate how a one-percentage point increase in military labor use would impact annual economic growth on average. Inserting the sample mean of military labor use for the variable MP (0.33% of population) and the sample mean of adult male educational attainment for the variable EDUC (3.18 years of primary education, entered in log form) into Equation (2) reveals that a one-percentage point increase in military labor use causes a substantial 9.43% annual increase in economic growth. However, a one-percentage point increase in military labor use is a rather large change, considering that the standard deviation of our panel data sample is only ¼ of a percentage point. Therefore, Equation (2) indicates that the influence of a change in military labor use of one standard deviation can be expected to cause a 2.4% increase in annual growth. The empirical result implied by Equation (2) lends empirical support for the idea that a brief stint in the military may allow young men to gain productive skills and discipline that could not otherwise be had in the civilian sector and that these skills positively impact economic growth.

Looking again at the theoretical shape of the defense burden function illustrated in Figure 1, the empirical findings for MS and MP that are illustrated in Table 2 can be brought into better perspective. The positive value of the partial derivative of MP on economic growth (as calculated with Equation (2) and evaluated at the average level of MP and EDUC) implies that the average country in our sample is somewhere to the left of point M_1 on the defense burden function. We can therefore conclude that military labor use appears to be exerting a net positive influence on economic growth when evaluated at the sample average of our panel data and controlling for the level of adult male educational attainment. The negative value of the partial derivative of MS on growth (as calculated with Equation 1 and evaluated at the sample average level of MS and GOV) implies that the average country in our sample is to the right of M_1 on the graph.

The influence of the other variables involved in the military interactions is evaluated at the mean values of the sample data, and is reported in Table 2. The figures in Table 2 illustrate that the net effect of civilian government spending (GOV) on growth is negative, despite the positive influence on growth, possibly from the Landau effect, when military and civilian government spending (MSGOV) are simultaneously high. Finally, the net influence of male education levels on growth remains positive, despite the negative influence of simultaneously higher levels male education attainment and military labor force use (MPEDUC).

C. Deriving the Positive-to-Negative Cross-Over Point of the Defense Burden Function

Our analysis of the non-linear defense burden function to determine the marginal impact of a percentage point change in MS or MP on economic growth begs the question: When does military spending and military labor use change from a positive influence on economic growth to a negative influence? We now turn to estimating the location of point M^2 on the defense burden function illustrated in Figure 1 for both military spending and military labor use. If we insert the sample means for all of the explanatory variables other than MS into our specification, we can then set the specification equal to zero and solve for the value of MS that satisfies this equation. Since the variable enters into the equation in quadratic form (and being careful to account for the cross product variable MSGOV), solving the quadratic function for MS reveals the maximum level of GNP that can be used for military spending without causing a drag on economic growth. Our empirical analysis of our sample indicates that the influence of military spending on growth becomes negative at 6.8% of GNP. This ratio appears to be relatively high considering that our sample mean for military spending is only 2.6% of GNP with a standard deviation of almost 2%.

If we insert the sample means for all of the explanatory variables other than MP into our specification, we can then solve for the value of MP. Since this variable also enters into the equation in quadratic form (and being careful to account for the cross product variable MPEDUC), solving the quadratic function for MP reveals that the influence of military labor use on growth becomes negative at 8.32% of GNP. This ratio appears to be very high considering that our sample mean for military labor use is only 0.33% of GNP with a standard deviation of 0.26%. As stated earlier, this result is most likely driven from the lack of education and training opportunities available to young men in the civilian sector of the economy for most countries in our sample.

D. Examining the Robustness of the Panel Data Results

The robustness of the panel data results can be explored to investigate whether information from the longitudinal or cross-sectional dimension of the panel data appears to be driving the statistical results. The second equation (EQ2) of Table 1 drops the country specific dummies while retaining the three separate time dimension dummies.[12] This allows the pooled, cross-sectional dimension of the panel data to influence the coefficient estimates while controlling for separate time periods. The adjusted R-squared statistic indicates that less than one-third of the observed variation in economic growth is explained by this specification, with only three of the military related variables remaining statistically significant (although a Wald test indicates that the MS and MSSQR variables are simultaneously significant at the 10% level).

The third equation of Table 1 (EQ3) also uses the same specification as EQ1, but this time the time dummy variables are dropped while the country dummies are retained. This allows the pooled, time dimension of the panel data to influence the coefficient estimates while controlling for the influence

[12] We also looked directly at the results of three separate, cross-sectional regression specifications, one for each time period. Degrees of freedom concerns necessitated our dropping the country specific effects from the regressions but we replaced them with regional dummy variables for the African and Latin American continents, as commonly employed in the growth literature (e.g. Barro [1991, 1997] and Blomberg [1996]). The regional dummies are significantly different from each other in the latter two time periods at the 5% confidence level. Many of the explanatory variables in each of these three equations produce coefficient estimates of the expected signs, including each of those few variables that achieve statistical significance in any given cross-section. However, none of these latter coefficients retain their significance across all three of the time periods. These combined results attest to the relative weakness of the cross-sectional dimension of the panel data to influence the statistical results as compared to the longitudinal dimension. The military variables are jointly, though typically not individually, significant. This again suggests the importance of the panel data approach to find evidence of the more complex interactions we are modeling. The pooled regression specification of EQ1 generates lower standard errors for every coefficient estimate.

of each country separately. The adjusted R-squared statistic for this equation indicates that two-thirds of the variation in growth is explained with this specification and all but one of the military variables produce significant estimates, all of which are of the predicted sign.

Comparing the three specifications in Table 1 is also revealing. Retaining the country dummies to control for cross-sectional variation and letting the pooled longitudinal information influence the coefficient estimates in EQ3 creates coefficient estimates that are more in line with the fixed-effects panel model of EQ1.[13] Only MSSQR and GASTIL fail to retain their same level of significance in EQ3. Yet, retaining the time dummies to control for longitudinal variation and letting the pooled cross-sectional information influence these same estimates, as in EQ2, generates results that are much less reflective of EQ1. This comparison supports Ram's speculation that the longitudinal information in statistical analysis would be necessary to extract robust empirical results regarding the influence of military sector size on economic growth. However, this comparison goes against Barro's (1997) findings that cross-sectional information appears to be the dominant influence determining the coefficient estimates of his growth model.

Finally, we address whether any regional differences might exist between the two continents. We do so by using the panel data analysis for each continent separately, and in each case the same specification as EQ1 was used (including both the time period and country-specific dummy variables) to determine whether these complex effects were robust across both regions separately. The two equations in Table 3 illustrate that not all of the institutional and military effects on growth are statistically significant in each region separately, though all of the signs of the coefficient estimates on the military variables are of the anticipated direction.

Many of the coefficients on the neoclassical growth and economic policy variables are not significant at conventional levels of confidence for the sub-

[13] An F-test of the time dummies indicates that they remain jointly significant at the one-percent confidence level.

Table 3. Region Specific Panel Results

	Africa	Latin America
GDP	-0.1572 ***	-0.2357 ***
	(0.0250)	(0.0238)
INV	0.0236	0.0514 ***
	(0.0149)	(0.0178)
GOV	0.0201 *	-0.0730 **
	(0.0369)	(0.0327)
EDUC	0.0694 **	-0.0063
	(0.0329)	(0.0620)
LIFE	-0.0896	0.2227
	(0.2918)	(0.2187)
FERT	-0.1990 ***	-0.0559
	(0.0501)	(0.0495)
M1GROW	0.0005 **	0.0003 ***
	(0.0002)	(0.0001)
INFL	-0.0011	-0.0002 ***
	(0.0014)	(3.36E-05)
INFLSQR	1.27E-05	3.29E-08 ***
	(3.39E-05)	(6.60E-09)
MS	0.0096	0.0568 **
	(0.0124)	(0.0281)
MSSQR	-0.0003	-0.0019
	(0.0004)	(0.0016)
MSGOV	0.0054	0.0222 **
	(0.0067)	(0.0112)
MP	0.3767 *	0.3873 **
	(0.1988)	(0.1579)
MPSQR	-0.2224	-0.1264 *
	(0.1147)	(0.0682)

Table 3. (Continue) Region Specific Panel Results

	Africa	Latin America
MPEDUC	-0.1230	-0.1948 **
	(0.0851)	(0.0907)
DEMOC	-0.0068	-0.0080 **
	(0.0078)	(0.0040)
R Squared	0.92	0.94
Adj. R Squared	0.80	0.83
No. of obs.	67	62
Mean of dep. var.	0.0038	0.0001

Notes: * = 10%, ** = 5%, and *** = 1% level, respectively. Standard error of the coefficient estimate appears in parenthesis. Regressions include both country and time dummies.

sample of countries from Africa, but are significant for the sub-sample of Latin American countries. The military spending variables in either continent equation in Table 3 fail to generate the same confidence levels as EQ1 does, but the military labor use variable relationships are somewhat stronger in both continent equations. Ultimately, comparing the pooled results in EQ1 to the separate region regression equations in Table 3 reveals that the benefit of pooling the data is primarily achieved via the reduction in the standard errors of the coefficient estimates. Every coefficient estimate appearing in EQ1 from Table 1 has a lower standard error than the corresponding coefficient estimate appearing in either equation from Table 3. This is true even when the coefficient happens to be *larger* in EQ1 than in either equation in Table 3. Furthermore, pooling the panel data is supported by a Chow test.[14]

[14] The test statistic = 1.68 ~ F(18,49), which cannot be rejected at the 5% level of confidence.

E. Empirical Implications

It should be noted that the implications from our panel data analysis of African and Latin American countries would not likely translate directly to the experience of developed nations. Furthermore, these implications may not apply to all of the countries of North Africa, since most of these countries are not represented in our sample. Our panel data analysis of Latin America and African countries implies that the defense burden on economic growth is non-linear, and we estimate the point at which defense spending and military labor use yields a maximum positive influence on economic growth.

However, our empirical analysis should not be interpreted as a suggestion to use these inflection points for determining the optimal level of spending or the optimal level of labor use for a nation's military sector. The influence of military resource use on the nation's economy should never be used as the sole criteria for determining optimal capital or labor allocation levels for the military sector. Additionally, the positive results of male labor participation in the military should not be interpreted as justification for increasing the incidence of military conscription in less developed countries. Our analysis indicates that the positive effects of military labor force participation on economic growth can be expected only in the relative absence of adequate civilian education and training opportunities for young men. The positive net effect of male educational attainment on economic activity, when viewed along with the negative cross-product of military labor use and educational attainment of adult males, suggests that increased education and training opportunities for young men would generate greater returns to economic growth than increasing male labor force participation in the military through conscription.

Rather, the results of our empirical analysis can provide relevant economic information as to the potential net economic impact of military spending and labor use, as governments consider using different portions of a nation's GNP or employing different levels of a nation's population for national defense. In this way, the economic implications of defense burden can then be weighed meaningfully along with the numerous national security concerns and other vital criteria when a nation's government must identify their optimal level of defense spending and military use of labor.

V. Conclusion

The unique contribution of our study is two-fold. First, we describe a simple yet robust model of the defense burden on economic growth that integrates the implications of disparate theories gleaned from the defense economics literature and discussed in Deger and Sen (1995) and in Ram (1995). Our model allows many of the various avenues by which military resource use influences a country's rate of economic growth to be revealed empirically. Second, we estimate the defense burden function that is implied by this model using an augmented version of an established neoclassical growth model developed by Barro (1991, 1997). We chose Barro's model specification because it is a neoclassical model that controls for cross-country variation in political and economic institutional influences on economic growth. Ultimately, our panel data analysis of Latin America and Africa countries reveals that the defense burden function is non-linear for both military spending and military labor use. Low levels of military spending and labor use can have a positive influence on economic growth, but this positive influence quickly turns negative at higher levels of military spending and eventually turns negative at higher levels of military labor use.

We find empirical evidence that military spending during the period analyzed has had a net negative influence on economic growth, and that military labor use has had a net positive influence on growth, when each level is evaluated at the sample average levels of military spending and labor use, respectively. However, the positive influence of military labor use diminishes substantially as the average level of male educational attainment in a country increases. Our panel data analysis covered three separate, five-year growth periods during the period 1975 to 1989, and the statistical results are based on a fixed effects model using 129 observations from a sample of 44 countries in Africa and Latin America. We control for the opportunity cost of lost human capital in the civilian sector of the economy (Blomberg, 1996) and take into account possible gains in civilian, public sector production efficiencies that could be statistically correlated with increased military spending (Landau, 1994). Our empirical analysis suggests that the longitudinal dimension of the panel data tends to influence these results more heavily than the cross-sectional dimension. Finally, a Chow test verifies that pooling the data from these two continental regions into one panel data sample is statistically justified.

Appendix

Table A. Descriptive Statistics: Mean (Standard Deviation)

	Full sample	Africa	Latin America
No. of obs.	129	67	62
GDP (growth)	0.0020	0.0038	1.29E-05
	(0.0351)	(0.0372)	(0.0330)
GDP (level)	7.430	6.939	7.961
	(0.7859)	(0.6461)	(0.5414)
INV	-2.114	-2.346	-1.863
	(0.5994)	(0.6791)	(0.3630)
GOV	-1.772	-1.557	-2.004
	(0.3752)	(0.2504)	(0.3495)
EDUC	1.154	0.8754	1.456
	(0.5574)	(0.5668)	(0.3555)
LIFE	4.028	3.916	4.149
	(0.1670)	(0.1330)	(0.1042)
FERT	1.657	1.834	1.446
	(0.3060)	(0.2256)	(0.2647)
M1GROW	45.013	21.340	70.595
	(112.62)	(52.010)	(149.68)

Table A. (Continue) Descriptive Statistics: Mean (Standard Deviation)

	Full sample	Africa	Latin America
INFL	81.54	9.545	159.34
	(448.06)	(12.346)	(639.73)
MS	2.582	2.877	2.263
	(1.970)	(2.197)	(1.651)
MP	0.3320	0.2329	0.4391
	(0.2617)	(0.1919)	(0.2854)
DEMOC	4.557	5.540	3.494
	(1.926)	(1.435)	(1.830)

Notes: Africa: Algeria, Benin, Botswana, Cameroon, Central African Republic, Congo, Ghana, Kenya, Malawi, Mali, Mauritius, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Tunisia, Uganda, Zaire, Zambia, Zimbabwe.
Latin America: (Central America) Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad & Tobago; (South America) Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela.

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