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Military Expenditure: Econometric Testing of Economic and Political Influences

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Abstract

Econometric results from an analysis of the determinants of military expenditure in 125 countries during 1972-88 are presented. The dependent variable is the ratio of military expenditure to GDP; included among the explanatory variables are economic and financial indicators, political variables summarizing the form of government, and demographic and geographic features of nations. The results strongly confirm the importance of these variables in explaining cross-country differences in levels of military expenditure.

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Summary

Econometric analysis of cross-section time series data shows that the ratio of military expenditures to GDP is approximately constant--the ratio increases moderately with GDP at low levels of GDP and is constant at high levels of GDP. The elasticity of military expenditures with respect to per capita income is somewhat greater than one; thus, military expenditures rise more quickly than per capita income.

Several proxy variables for the ability of governments to obtain external financing confirm that military expenditures are reactive to economic conditions. Heavily indebted middle-income countries are found to allocate less to the military. Small low-income economies, which normally have limited financial leverage because of both their low per capita income and their small populations, also spend less on the military. Additionally, the net flow of public and publicly guaranteed external financing, which indicates the level of concessional financing available to a nation, has a positive association with military expenditures. The empirical results indicate that external financing increases military spending in two ways. First, financing increases government spending, which indirectly increases military appropriations. Second, external financing induces a shift in the mix of government expenditures toward the military, implying that military expenditures receive a disproportionate share of external financial resources relative to other budgetary items.

The elasticity of military expenditures with respect to central government expenditures is found to be less than unity. This implies that military expenditures adjust somewhat less than proportionally to central government expenditure changes. Conversely, in the second equation of the simultaneous system employed in this paper, the elasticity of central government expenditures with respect to military expenditures is found to be close to the average ratio of military expenditures to central government expenditures. This result implies that autonomous increases in military spending, on average, are accommodated by an approximately equal increase in central government expenditures rather than a crowding out of other government activities.

The model indicates that the form of government affects the level of military expenditures. Countries involved in an internal or external conflict tended to spend more on the military. For countries not engaged in war, other things being equal, monarchies spent the most, followed by military governments and socialist governments. Countries governed by multiparty democracies tended to spend the least. Geographical variables, such as land area and border length, are also found to have had a significant effect on the level of military expenditures.

I. Introduction

A great deal of variation exists in the proportion of GDP that countries allocate to the military, some allocate as much as one fourth of their GDP, while others spend less than 1 percent. At times the reasons for these differences are intuitively obvious, in other circumstances they appear quite mysterious. Up till now, no consensus has been reached in the empirical literature on the determinants of military expenditure because of conflicting empirical results. This has prompted certain authors to state that military expenditures are autonomously determined. Others have questioned the applicability of econometric analysis to a field where country-specific conditions seem to dominate.

This study offers a more extensive data base than that used in other studies and an econometric specification that takes explicit account of simultaneity bias between military expenditures and central government expenditures. The resulting empirical findings indicate that a large proportion of the observed variation can in fact be attributed to political and economic differences.

The data on military expenditures are drawn from the Stockholm International Peace Research Institute (SIPRI) and those collected in conjunction with a companion study (Hewitt (1991)). The sample is quite large: over two thousand observations from 125 countries during 17 years. The econometric specification is based on a public choice framework where the leadership chooses the level of central government expenditures and the budget share for the military. The leadership optimizes its own welfare function which, of course, takes into account both the welfare of the citizens and the leadership's own priorities. The political priorities of the leadership are assumed to be based on the political circumstances, as indicated by the presence of international war or civil war, and on the form of government.

The income constraint is determined by the level of GDP, the efficiency of the revenue system (assumed to be a function of the level of economic development), and the level and cost of foreign financing. The cost of providing defense or security -- a function of geographical features of a nation and the population level -- also influences the demand for military expenditure.

These features combine to form a two-equation system where the level of military expenditures and the level of central government expenditures are determined simultaneously. The leadership chooses the budget size based on the availability of funds, the welfare of the citizens, the political situation, and the leadership's priorities and ideology. Simultaneously, the leadership chooses the military's share of central government expenditures based on the level of overall government spending and on other economic, geographical, and political factors.

The results indicate that, contrary to the conventional wisdom, economic, financial, political, and geographic variables are significant determinants of military expenditures. The R-squared of 0.55 is sufficient to conclude that generalizations can be made regarding the determinants of military expenditure in the last two decades. However, the unexplained residual of 45 percent indicates that there are some omitted variables, the most important of which are probably country-specific indicators of the perceived threat of military attack, cultural-historical considerations that influence the tastes of the population and leadership, and efficiency of the military in utilizing resources. The efficiency factor is particularly important because increased efficiency represents a method of decreasing military expenditures without diminishing the level of national security.

The study is organized in the following manner. Section II reviews the literature. Section III delineates the theoretical model used as the basis for the econometric estimations. Section IV describes the data and the econometric results, and Section V summarizes the findings.

II. Review of the Literature

A number of books both provide comprehensive descriptions of the existing empirical studies of military expenditure and offer their own empirical tests: Deger (1986), Looney (1986), and McKinlay (1989). As stated above, the findings often conflict. Occasionally, empirical studies produce opposite signs for similar variables. However, more commonly, different studies simply fail to confirm each other's findings.

Much of the existing econometric analysis of the determinants of military expenditures suffers from a number of structural weaknesses that help explain their relatively poor results. The main shortcoming is that virtually all of these studies are based on small data sets confined to a limited number of countries covering only one year. 1/ Furthermore, a number of studies use overly simplistic econometric specifications that do not correct for simultaneity bias in the determination of central government expenditures and military expenditures. 2/

1/ This leads to many potential many econometric problems. The limited number of countries raises questions about selectivity bias. The limited time frame and differences in country coverage help explain conflicting results. The small sample size diminishes the significance of the estimates and thereby increases the likelihood that tendencies present in the data will go undetected.

2/ Correction for simultaneity can cause signs and significance of variables to change. Indeed, in the present study this happens in the case of population (see below).

Among the existing empirical studies, some are well formulated and provide a useful set of results; a few of the more interesting ones are reproduced in Table 1. 1/ Dudley and Montmarquette (1981) have per capita military expenditures in U.S. dollars as the dependent variable in a full-information maximum-likelihood framework (Table 1.A). They find that the income elasticity of demand for military expenditures is approximately unitary and that the tax price elasticity of demand is somewhat less than unity. 2/ The level of allies' defense spending and a constitutional constraint on military spending are found to have negative effects. Nondemocratic regimes are found to have an uncertain influence on military spending (the coefficients are insignificant in different equations and the signs alternate); the coefficients on all the regional variables also prove to be insignificant.

In Gonzalez and Mehay (1990), military expenditures in U.S. dollars is the dependent variable (Table 1.B). They find a nearly proportional positive association with population and per capita income. Nondemocratic regimes are found to spend more, and a constitutional spending limit is found to induce lower spending. The effect of military outlays of allies and rivals is complicated; the coefficient for expenditures of rivals is positive for developing countries, while the relationship is insignificant for industrial countries; military expenditures of allies have a marginally significant positive effect in developing countries and a marginally insignificant negative coefficient in industrial nations.

Two other studies are interesting even though their econometric specification is suspect because they do not explicitly correct for simultaneity. The dependent variable in Maizels and Nissanke (1986) is the ratio of military expenditures to GDP (Table 1.C). They find that involvement in an international war or civil war, an index based on military government and the use of violence, and the size of the central government budget all have positive and significant coefficients. Among the financial variables, the availability of foreign exchange has a positive association; the ratio of foreign-owned capital to the capital stock has a negative association; an arms supplier concentration ratio has a positive coefficient; and a Middle East dummy variable has a positive coefficient. However, GDP per capita, GDP growth, and a foreign investor concentration ratio do not have significant coefficients. Looney (1986) has per capita military expenditures in U.S. dollars as the dependent variable (Table 1.D). Per capita GNP, the current account balance, net foreign capital inflows, growth in exports,

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1/ Each study included at least several different specifications; the equations reported in Table 1 are the most complete equations that use the most recent data from each study.

2/ The tax price is calculated for each country and represents the added cost of increasing government spending to an average individual.

Table 1. Empirical Studies of Demand for Defense

A. Dudley and Monmarquette (1981)

Dependent Variable: Per capital military expenditure, 1975
(SIPRI data, 38 countries)

Explanatory Variable	Coefficient	t-ratio
Constant	- 29.36	0.44
Per capita income	0.0499	4.16
Reciprocal of population	749	3.33
Allies' spending	-0.0077	3.5
Nondemocratic regime	-27.64	0.51
Latin America & Caribbean	39.62	0.53
Africa	1.567	0.02
Asia	81.79	1.47
Constraint on military spending	- 216.8	3.02
Consumption scale economies	- 0.3138	1.93
R-squared	0.507	
Calculated Elasticities		
Tax-price elasticity	-0.786	
Income elasticity of demand	1.106	
Spill-over effect	0.0081.	

B. Gonzalez and Mehay (1990)

Dependent Variable: Military Spending in U.S. dollars, 1982
(ACDA data, 74 Countries)

Explanatory Variable	Coef.	(t-ratio)	Coef.	(t-ratio)	Coef.	(t-ratio)
	Full Sample		Industrialized Countries		Developing Countries	
Constant	-3.9	(6.9)	-2.9	(2.5)	-3.8	(5.5)
Population	1.0	(20.4)	1.25	(20.8)	0.9	(14.8)
Allies' military exp. (lagged)	0.03	(2.1)	-0.07	(1.9)	0.03	(1.7)
Rivals' military exp. (lagged)	0.04	(2.8)	0.02	(0.3)	0.06	(3.5)
Per capita GDP	1.06	(16.3)	0.89	(7.0)	1.04	(13.0)
Govt. social exp. ratio to GDP	0.19	(1.3)	0.37	(1.8)	0.14	(0.79)
Military exports ratio to GDP	0.12	(1.8)	0.01	(0.02)	0.02	(0.24)
Alliance-Allies expenditure interaction variable	-0.04	(2.4)	0.06	(1.4)	-0.01	(0.65)
Nondemocratic regime dummy var.	0.39	(2.7)	n.a.		0.23	(1.3)
Constitutional spending limit dummy variable	-0.73	(1.9)	-0.6	(1.7)	n.a.	
Volunteer army dummy variable	-0.11	(0.7)	-0.02	(0.1)	-0.034	(0.18)
R-squared	0.93		0.96		0.93	
Number of observations	74		23		51	

Table 1. Empirical Studies of Demand for Defense (concluded)

C. Maizels and Nissanke (1986)

Dependent Variable: military expenditure as proportion of GDP
1978-80 averages (ACDA data, 73 countries)

Explanatory Variable	Coefficient	t-ratio
Constant	not reported	
War-civil war	1.74	2.00
Military gov't/use of violence index	0.66	2.76
GDP per capita	not reported	insignificant
GDP growth	not reported	insignificant
Central gov't expenditure to GDP	0.17	5.63
Growth of foreign exchange	2.40	3.49
Foreign investment to capital ratio	-0.79	-2.27
Foreign investor concentration ratio	not reported	insignificant
Arms supplier concentration ratio	0.64	2.96
Middle East dummy variable	3.33	2.34
R-squared	0.673	

D. Looney (1986)

Dependent Variable: Per capita military expenditure, 1981
(SIPRI data, 61 developing countries)

Explanatory Variable	Coefficient	t-ratio
Constant	not reported	
GNP per capita	0.26	4.52
Current account balance	0.77	14.3
Gov't consumption ratio to GDP	0.29	4.40
Net capital inflows	0.14	2.66
External public debt to GDP	-0.12	-1.86
Growth in exports	0.12	2.29
R-squared	0.896	

and government consumption expenditure in proportion to GDP have positive effects. The association with the ratio of external public debt to GDP is negative, though only marginally significant.

Although none of the studies covers the exact topics of the present study, their combined findings are consistent with the results obtained herein and lend support to the notion that political, economic, and other variables can explain a large portion of the observed military expenditure data. 1/

III. A Public Choice Model of Demand for Military Expenditure

In this section, an econometric model designed to test the determinants of military expenditures in a cross-section of countries is developed. The model identifies the political, economic, financial, and geographical factors that are likely to influence government decisions on the level of military expenditures and provides a framework to test the relevant hypotheses. Initially, the model does not consider the interaction between military expenditures of allies and those of rival nations. An extended version provides some indicative tests of this factor (see Section IV.3).

The model employs a public choice framework that analyzes how the government chooses the level of resources to allocate to the military. The primary assumption is that the leadership selects policies with the goal of maximizing its own welfare, subject to national economic and political constraints. This assumption does not imply that the political leadership is necessarily selfish or uninterested in the welfare of its citizens; any consideration can enter into the welfare calculation of the leadership. To the extent that the leadership is concerned about the welfare of citizens, the welfare function will reflect this concern.

In the model, the leadership of the country has to make two very important budgetary choices:

1. the **size of the budget** and therefore the ratio of private versus public use of resources in the economy,

2. the **mix of government expenditures** between the military and other uses.

1/ In a recent study, Cashel-Cordo and Craig (1990) examine the effects of foreign aid on the pattern of government expenditures in developing nations. Since they use cross-section time series data, the number of observations is large. However, their formulation is somewhat different from those reviewed above; other than foreign aid, the extensive number of variables are primarily sociological, and therefore the results are not comparable.

The variables that enter the **welfare function of the leadership** are

$$W = \Omega[U, D, S; \text{political variables}], \quad (1)$$

where
- W the welfare level of the political leadership,
- Ω the welfare function,
- U utility derived from private consumption,
- D the level of defense derived from military expenditure,
- S social welfare derived from social expenditures (approximated by nondefense government expenditures).

The welfare function places relative weights on each of the three variables that determine welfare: private consumption, defense, and social expenditures. 1/ The political variables are viewed as state-of-nature factors that affect the environment in which the leadership operates or that are indicative of the ideology of the leadership. Therefore, they determine the weights of the different elements in the welfare function.

The welfare function in its present form is not operational. A more convenient form can be obtained through transformations based on supply-cost relationships. Simple transformations will suffice for U and S since these are not the focus of the study,

$$\begin{aligned} U &= U(C) \\ S &= S(SE), \end{aligned} \quad (2)$$

where
- C private consumption,
- SE the level of social expenditures.

A more careful consideration is warranted for defense. Defense, or the level of security, is influenced by a number of factors that affect the cost of obtaining security. It is hypothesized that the cost function for defense is

$$D = D(ME, POP, \text{geographic variables}), \quad (3)$$

where
- ME the level of military expenditure,
- POP population,

1/ In order to keep the model simple, only two types of government expenditures are modeled. The purpose of the model is to concentrate on allocations of resources to the military. The other category includes interest payments, general government expenditures, and economic expenditures. The practice of referring to the other category as social expenditures is purely for expositional ease. Please note also that there is no business sector in this framework and therefore no investment expenditure; all savings are lent to the government.

Geographical variables:

LA land area,
LB length of land borders,
CB length of coastal borders.

Equation (3) captures the notion that the effectiveness of military expenditure in providing security benefits will vary from country to country. For instance, larger countries are likely to be more costly to defend than small islands and therefore Chile is expected to have a higher defense budget than Mauritius, all other things being equal. The effect of population size is ambiguous. A larger population could be more costly to defend; however, a large population also acts as a deterrent to external attack.

The new welfare function, W, using equations (1), (2), and (3), is

$$W = W(C, ME, SE; POP, \text{geographic variables}, \text{political variables}). \quad (1')$$

The econometric specification uses a Cobb-Douglas functional form,

$$W = A\, C^{\alpha_1}\, ME^{\alpha_2}\, SE^{\alpha_3}, \quad (4)$$

In this formulation the state variables, which describe political, demographic, and economic conditions, are assumed to influence the parameters of the equation: α_1, α_2, and α_3; thus they determine the relative priority placed on C, ME, and S. 1/

The **income constraint** in this model is fixed by a number of interrelated equations. The government budget identities are,

$$CGE = ME + SE, \quad (5A)$$

$$CGE = T + DF + FF, \quad (5B)$$

where CGE is central government expenditure, T is government revenue, DF is domestic financing, and FF is foreign financing. Since the government is seen as managing resource allocations within the economy, its budget constraint is determined by the total level of resources available to the economy,

$$CGE = GDP - C + FF. \quad (5C)$$

1/ Each parameter is also assumed to take on a Cobb-Douglas functional form to arrive at equation (9) below.

Finally, since tax revenue is both a choice variable and a constraint,

$$T/GDP = H(DI, \text{ form of government}), \qquad (5D)$$

where DI is a development index. Equation (5D) is a behavioral relationship. The level of development is hypothesized to affect the ease with which government can raise revenues; a higher level of development is generally associated with a higher tax base and greater administrative capacity to collect taxes. The form of government is also hypothesized to influence the ability to raise revenues; for instance, a socialist government may be in a better position to collect revenue than a nonsocialist government because a high proportion of economic assets is government owned.

Combining the above equations yields the following maximization equation for the government leadership:

$$\underset{C,ME,CGE}{\text{Maximize}} \quad \Gamma = W[C, ME, (CGE-ME)] + \lambda[CGE - GDP + C - FF]. \qquad (6)$$

Assuming a Cobb-Douglas welfare function, equation (4), the solution is

$$ME = [\alpha_2/(\alpha_2+\alpha_3)]CGE \qquad (7A)$$

$$CGE = [\alpha_1/(\alpha_1+\alpha_3)]ME + [\alpha_3/(\alpha_1+\alpha_3)](FF + GDP). \qquad (7B)$$

Equation (7) is a simultaneous equations system that determines the level of central government expenditure in the economy and proportion of the budget allocated to military expenditures. In the first equation, military expenditures are a simple proportion of the government budget, based on the relative priority of defense vis-à-vis social expenditures. In the second equation, central government expenditures have two determinants. In part, a proportion of total national economic resources (GDP + FF) is allocated to CGE based on the relative priority accorded to social expenditures vis-à-vis private expenditure. The other part of the equation indicates that CGE is also a function of ME; this system is illustrated in Figure 1. 1/

By dividing equations (7A) and (7B) by GDP and allowing for the state variables' effect on the parameters of the function, the following general form of the simultaneous equations is obtained,

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1/ Comparative statics of the results show that, for instance, whenever $\alpha_2=\alpha_3$, CGE will be split evenly between ME and SE. If $\alpha_1=\alpha_2=\alpha_3$, then expenditures will be evenly split among the three options. However, these conclusions are entirely dependent upon the assumed functional form.

$$ME/GDP = F[\underset{+}{CGE/GDP}, \underset{?}{GDP\$}, \underset{?}{POP}, \underset{?}{FF}, \underset{+}{\text{geographical variables}}, \underset{+/?}{\text{political variables}}], \quad (8A)$$

$$CGE/GDP = G[\underset{+}{ME/GDP}, \underset{+}{DI}, \underset{-/+/?}{\text{government variables}}, \underset{+}{(1+FF)/GDP\$}], \quad (8B)$$

where
- ME — military expenditures in local currency,
- GDP — GDP in local currency,
- GDP$ — real GDP in U.S. dollars, 1980 purchasing power parity prices,
- POP — population,
- CGE — central government expenditures in local currency,
- FF — foreign financing (in US dollars)
- DI — a development index (see below), and

form of government (mutually exclusive dummy variables): 1/

multiparty democracy	(benchmark)
socialist government	(+)
military government	(?)
monarchy	(?)
other	(?)

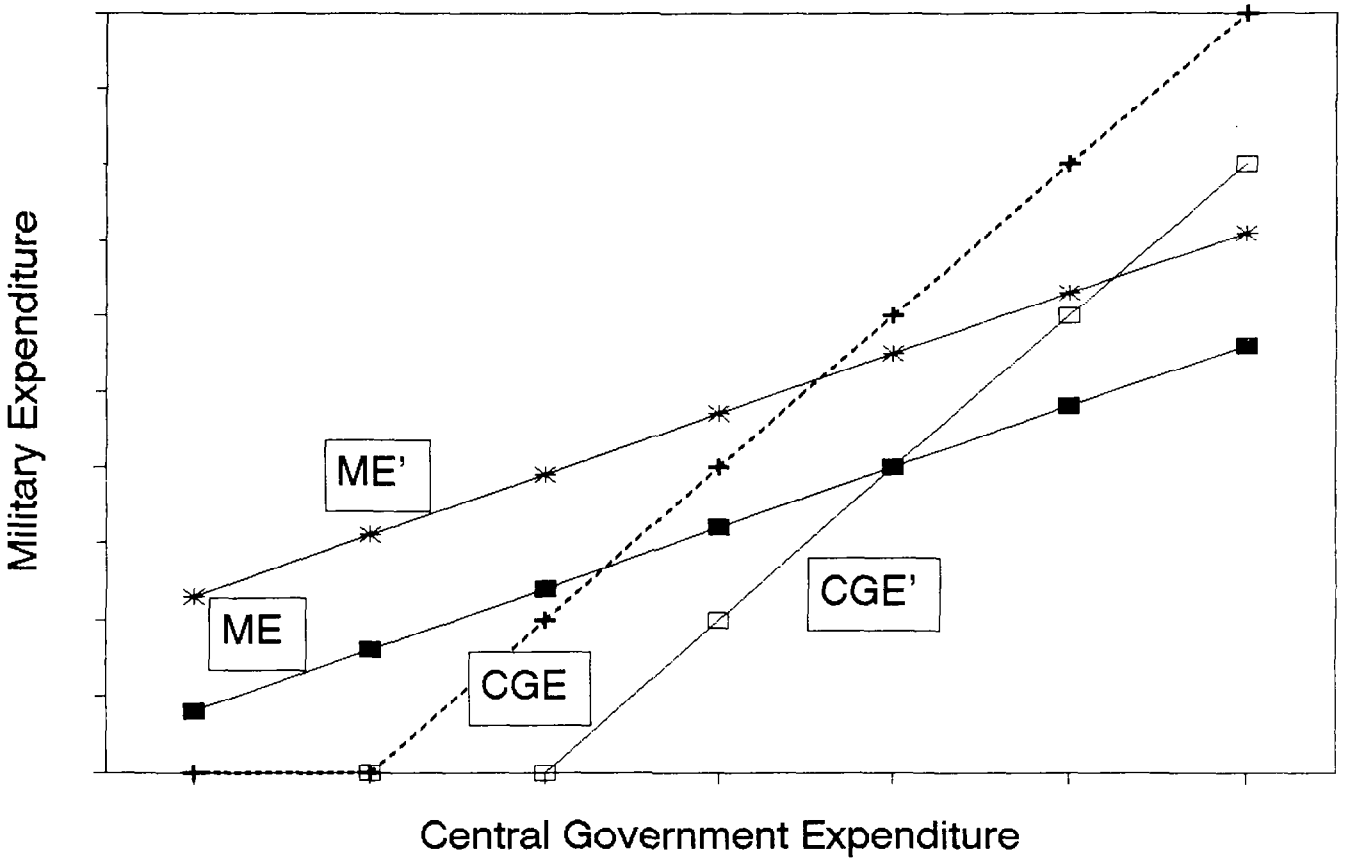
political variables (mutually exclusive dummy variables):

war:	international war	(+)
	civil war	(+)
nonwar:	multiparty democracy	(benchmark)
	socialist government	(?)
	monarchy	(?)
	military government	(+)
	other	(?)

The formulation separates direct and indirect influences on the level of military expenditures. The **indirect influences** are transmitted through the central government budget. Among the determinants of the level of central government expenditures are military expenditures, which are expected to have a positive influence; a development index; the form of government variables; and foreign financing. Consider, for instance, a nation that experiences a rise in its development index rating. Because it is now easier to raise revenues, the curve in Figure 1 will shift to the right, from CGE to CGE'; this will cause the level of both central government expenditures and military expenditure to rise, even with constant political preferences.

1/ See Section IV.1 for the definition of the form of government and political variables.

Figure I.
Military & Central Government Exp.



The **direct influences** on the level of military expenditures reflect the derived demand from the welfare function, which incorporates both the cost function and income constraints. For example, consider two identical countries that differ only in the length of their land borders. The larger country will have a higher α_2 value and, consequently, its ME curve will be above that of the smaller country, ME' as opposed to ME in Figure 1. Consequently, the larger country will have higher military expenditures and higher central government expenditures, even though the priority attached to defense is identical.

The direct influence of real GDP on ME/GDP is quite complicated and interesting. Military expenditures are often viewed as a pure public good. Therefore, a larger country (in terms of GDP) will have more defense for a given proportion of GDP spent on the military (due to economies of scale). 1/ This implies a negative sign. Conversely, a higher GDP represents more resources available for financing military expenditures, and this implies a positive sign. Since the two effects have opposite signs, the expected sign is uncertain.

Similarly, the coefficient on population could be either positive or negative. A larger population can be more costly to defend -- particularly if the military is involved in domestic politics. On the other hand, a large population implies an automatic deterrent.

The financing variables present an interesting specification challenge. In the mechanical delineation of the model above, the level of foreign financing enters the determination of central government expenditures in the manner described in equation (8B). However, this formulation glosses over considerations of the cost of foreign financing and the ease of obtaining foreign financing. To account for this factor, a number of variables have been incorporated into the analysis that act as proxies for the cost of foreign financing. These variables are a dummy variable for the heavily indebted middle-income nations covering 1972-79, HD70; a dummy variable for heavily indebted nations covering 1980-88, HD80; a dummy variable for small low-income economies, SLIE; 2/ and the net flow of public and publicly guaranteed foreign financing, PGFF. The hypothesized effect of the three dummy variables on the level of central government expenditure is negative while the effect of PGFF is predicted to be positive. These four variables have also been incorporated into the military expenditures equation to determine whether the financing variables affect the mix of government expenditures. The hypothesis is that easier financing terms will allow governments to engage in the luxury of higher military expenditure, and therefore, HD70, HD80, and SLIE are expected to have negative signs and PGFF is expected to have a positive sign.

1/ This issue is discussed in detail in Hewitt (1991) and Stiglitz (1988).

2/ The country categories are listed in Appendix Table 3.

Assuming a log linear form of equations (8A) and (8B) yields the following system:

$$\ln(ME_{it}/GDP_{it}) = \beta + \beta_1 \ln(GDP\$_{it}) + \beta_2 \ln^2(GDP\$_{it}) + \beta_3 \ln(POP_i)$$
$$+ \beta_4 \ln(CGE_{it}/GDP_{it}) + \beta_5 \ln(CB_i) + \beta_6 \ln(LB_i) + \beta_7 \ln(LA_i)$$
$$+ \beta_8(HD70_i) + \beta_9(HD80_i) + \beta_{10}(SLIE_i) + \beta_{11}(PGFF_{it})$$
$$+ \text{political dummy variables}_{(it)} + \text{year dummy variables}_{(t)} + u_{it}, \quad (9A)$$

$$\ln(CGE_{it}/GDP_{it}) = \gamma + \gamma_1 \ln(ME_{it}/GDP_{it}) + \gamma_2(DI_{it}) + \gamma_3(HD70_i)$$
$$+ \gamma_4(HD80_i) + \gamma 5(SLIE_i) + \gamma 6(PGFF_{it}) +$$
$$\text{form of government dummy variables}_{(it)}$$
$$+ \text{year dummy variables}_{(t)} + e_{it}. \quad (9B)$$

where:

PGFF	net flow of public and publically guaranteed external financing,
HD70	heavily indebted nations 1972-79 (dummy variable),
HD80	heavily indebted nations 1980-88 (dummy variable),
SLIE	small low income economies (dummy variable),
countries	$i = 1,\ldots,125$,
years	$t = 1972,\ldots,1988$,
CB	coastal borders,
LB	land borders,
LA	land area.

IV. Econometric Results

This section presents and discusses the econometric tests of the determinants of military expenditure. A description of the data is followed by a review of the econometric results. The two-stage least squares technique is used to estimate the system defined in the previous section. Various other tests were run on the data. The three-stage least squares technique was used to re-estimate the equations. Since the results were virtually identical, only the two-stage results are reported. 1/

1. The military expenditure data

The data on military expenditures is described in Hewitt (1991), see Appendix Table 6 for summary statistics. Two different estimates of

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1/ Additionally, use of the fixed-effects technique was rejected because the purpose of the analysis is to explain cross-country differences.

military expenditures are constructed using data compiled by the Stockholm International Peace Research Institute (SIPRI). The first set is SIPRI's data, with a few minor modifications. 1/ The **SIPRI** definition of military expenditures is total government outlays on the military whether for national defense, paramilitary forces, or for military aid to other nations. The second data set, **Adjusted SIPRI**, accounts for foreign-financed military expenditures and therefore represents the total level of resources used by the military, regardless of the source of financing. Thus, the difference between the two is that the SIPRI military expenditure figures do not include foreign aid financed purchases of military supplies and equipment while the Adjusted SIPRI figures do. However, the derivation of the Adjusted SIPRI figures is not important for the present study because the econometric results are virtually identical. The econometric estimates using the SIPRI and the Adjusted SIPRI data are found to have the same signs, the same degree of significance, and generally the same values up to one decimal place and sometimes up to three decimal places (see Table 2 below).

Most of the other data are derived from Government Finance Statistics Yearbook and International Financial Statistics, supplemented with World Bank and United Nations data for countries that are not Fund members. Other data come from the individual national accounts available in the Joint Bank/Fund Library. Country categories are listed in Appendix Table 3. The PGFF values come from the World Bank's World Debt Tables. 2/

The development index, the political variables, and form-of-government variables are constructed variables. The political variables are interdependent dummy variables constructed from descriptions in Sivard (1987), SIPRI Yearbooks, and the Europa World Yearbook. The benchmark is a multiparty democracy not engaged in internal or external conflict. In a monarchy, power is transferred through heredity. A military government refers to the means by which the authority gained power and the status of the ruler before taking power. A socialist government is one that does not fit into the other categories and where the self-proclaimed ideology of the leadership is consistent with socialist ideology. The category of "others" refers to states that do not unambiguously fit into one of the above groups, for instance, one-party states and politically unstable states. The number of countries in each category is listed in Appendix Tables 3 and 4; certain countries changed status over the course of the study.

The concept for the development index comes from the United Nations Development Programme (UNDP) human development index. Among the attractive features of the UNDP index is its reliance on purchasing

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1/ SIPRI does not supply estimates for the U.S.S.R. and China.

2/ The level of PGFF is set at zero for all industrial nations and net creditor nations. Since net flows can take on negative values, it was not possible to use logarithms with this variable.

power parity (PPP) rates instead of official exchange rates in cross-country comparisons and the use of other indicators of the quality of life. The development index used herein is constructed in the following manner. The ratio of PPP per capita GDP (1980 real prices) to $7000 is calculated, and a weight of 0.8 is applied. 1/ Next, the ratio of life expectancy to 70 years is calculated, and a weight of 0.2 is applied. This index differs substantially from the UNDP index. 2/

2. Summary of the empirical results

Overall, the econometric equations preformed quite well (Table 2). The R-squared of 0.56 is encouraging with cross-section time series data. 3/ Furthermore, these results are a significant improvement over the reduced form equations in Appendix Table 8, which, as to be expected, produce similar coefficients.

a. Economic and financial variables

In general, the findings support the hypotheses of the model, particularly for the economic and financial variables. With respect to the coefficients, it will be recalled that the form of the estimation equation is in natural logs. Therefore, the coefficients represent elasticities, with the exception of the dummy variables and PGFF, as explained above. Military expenditures are found to be positively

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1/ As with the UNDP index, all countries with a per capita GDP above a certain level ($7000) are assigned a value of unity. Implicit in this formulation is that $7000 is the level at which a country is considered developed. The same is true of the health index. An expected life span of 70 years is considered an indication of reasonable health standards.

2/ The UNDP index is based upon the log of per capita GDP as a ratio to $5000, in 1987 prices; life expectancy as a ratio of 78 years; and the literacy rate. The variables are given an equal weight. Since yearly estimates of literacy rates are not widely available for individual countries, this variable could not be used in the present analysis.

The UNDP index attaches minimal importance to differences in per capita income because of the use of logarithms and the equal weight applied to the three variables. This leads to some odd results, for instance, Bulgaria, Mexico, Portugal, and Uruguay have virtually the same purchasing power as the United States and Switzerland in the UNDP index. Pakistan, with a per capita GDP of some $350 and a PPP per capita GDP of $1600, has a rating on the purchasing power index that is two thirds that of Denmark, where the per capita GDP is $15,000.

3/ This is the regression-based R-squared, which measures the covariance between the actual and predicted regression values. The more traditional error-based R-squared is nearly the same, 0.54; this confirms that the R-squared is a meaningful measure of the goodness of fit.

Table 2. Simultaneous Equation Estimations

	Coefficient	t-ratio	Beta coefficient	Coefficient	t-ratio	Beta Coefficient
Equation 1						
Dependent variable:	Ratio of SIPRI military expenditure to GDP			Ratio of Adjusted SIPRI military expenditure to GDP		
Constant	-7.9	--	-4.3	-8.0	--	-4.3
Real GDP in US dollars	0.23	3.2	0.50	0.27	3.5	0.53
Real GDP in US dollars squared	-0.0075	-2.1	-0.32	-0.011	-2.9	-0.43
Population	0.025	0.7	0.043	0.031	0.83	0.049
Ratio of central government expenditure to GDP	0.76	6.1	0.44	0.80	6.1	0.44
Net flow of public and publicly guaranteed external capital	1.02	2.7	0.049	1.69	6.3	0.10
Heavily indebted nations 1972-79	-0.39	-6.0	-0.11	-0.42	-6.3	-0.11
Heavily indebted nations 1980-88	-0.45	-7.6	-0.13	-0.47	-7.8	-0.13
Small low-income economies	-0.15	-3.1	-0.073	-0.12	-2.5	-0.056
International war	1.50	21.4	0.44	1.73	23.6	0.48
Civil war	1.08	15.6	0.34	1.26	17.6	0.37
Socialist government	0.32	5.1	0.01	0.41	6.3	0.13
Military government	0.69	12.8	0.35	0.78	13.9	0.37
Monarchy	1.15	15.7	0.30	1.11	14.7	0.27
Other forms of government	0.37	6.78	0.15	0.39	7.05	0.15
Land area (in square kilometers)	0.057	4.86	0.12	0.063	5.20	0.13
Land borders (in kilometers)	0.030	6.27	0.13	0.034	6.90	0.14
Coastline (in kilometers)	*0.012*	*3.22*	*0.062*	*0.017*	*4.60*	*0.083*
1972	0.047	0.59	0.012	0.046	0.56	0.011
1973	0.022	0.28	0.006	0.020	0.25	0.005
1975	0.012	0.15	0.003	0.019	0.24	-0.005
1976	0.057	0.72	0.015	0.079	0.97	0.020
1977	0.062	0.77	0.016	0.099	1.20	0.025
1978	0.069	0.86	0.019	0.111	1.34	0.028
1979	0.075	0.93	0.020	0.128	1.55	0.032
1980	0.055	0.68	0.015	0.109	1.30	0.028
1981	-0.003	-0.04	-0.001	0.041	0.48	0.010
1982	0.009	0.11	0.003	0.049	0.55	0.012
1983	-0.002	-0.13	-0.001	0.039	0.44	0.010
1984	-0.013	-0.15	-0.003	0.034	0.59	0.009
1985-	0.009	-0.11	-0.002	0.034	0.40	0.009
1986	0.001	0.02	0.000	0.042	0.49	0.011
1987	-0.053	-0.63	-0.014	-0.030	-0.03	-0.001
1988	-0.069	-0.80	-0.017	-0.041	-0.46	-0.010
F-statistic	72.52			82.15		
R-squared	0.557			0.585		
Number of observations	2,025			2,026		
Equation 2						
Dependent variable:	Ratio to central government expenditure to GDP			Ratio to central government expenditure to GDP		
Constant	2.8	49.9	--	2.8	50.1	--
Development Index	0.47	9.74	0.27	0.45	9.51	0.26
SIPRI military expenditures to GDP	0.183	9.54	0.32	NA	NA	NA
Adjusted SIPRI military expenditures to GDP	NA	NA	NA	0.186	10.9	0.34
Net flow of public and publicly guaranteed external capital	1.72	6.98	0.14	1.39	5.33	0.044
Heavily indebted nations 1972-79	-0.097	-2.41	-0.047	-0.074	-1.84	-0.035
Heavily indebted nations 1980-88	0.049	-1.28	-0.24	-0.021	-0.54	-0.010
Small low-income economies	0.001	0.34	0.008	0.022	0.76	0.018
Socialist government	0.101	2.79	0.060	0.090	2.51	0.054
Military government	-0.226	-8.74	-0.25	-0.277	-9.12	-0.26
Monarchy	*-0.160*	-3.63	*-0.081*	*-0.159*	-3.85	*-0.080*
Other forms of government	-0.043	-1.30	-0.031	-0.040	-1.20	-0.029
1972	-0.046	-0.87	-0.021	-0.048	-0.90	0.022
1973	-0.029	-0.54	-0.013	-0.031	-0.57	-0.014
1975	0.080	1.51	0.037	0.081	1.53	0.037
1976	0.079	1.50	0.037	0.082	1.55	0.038
1977	0.070	1.32	0.033	0.076	1.42	0.035
1978	0.092	1.73	0.043	0.092	1.72	0.042
1979	0.072	1.36	0.034	0.080	1.51	0.037
1980	0.10	1.90	0.048	0.11	2.04	0.051
1981	0.14	2.63	0.066	0.15	2.87	0.072
1982	0.16	2.98	0.075	0.18	3.32	0.082
1983	0.14	2.60	0.065	0.16	2.95	0.074
1984	0.11	2.09	0.052	0.13	2.49	0.062
1985	0.10	1.91	0.048	0.12	2.21	0.055
1986	0.13	2.46	0.061	0.14	2.60	0.065
1987	0.12	2.23	0.055	0.13	2.48	0.061
1988	0.24	4.23	0.103	0.22	3.84	0.094
F-Statistic	38.47			38.30		
R-squared	0.316			0.313		
Number of observations	2,025			2,026		

related to GDP. The exact relationship is concave, with the elasticity of ME/GDP with respect to GDP having a range from 0.15 for the minimum level of GDP ($450 million) to 0.0 for the maximum level ($3.3 trillion). 1/ Thus, for countries with low levels of GDP, ME/GDP rises as GDP rises and military expenditures appear to be a somewhat superior good. For countries with high levels of GDP, the elasticity approaches zero and the proportion of military expenditures to GDP remains nearly constant as GDP rises.

The coefficient on population is positive though significant only at the 70 percent level of confidence. The derived elasticity of military expenditures with respect to per capita income ranges from 1.0 to 1.15. Therefore, military expenditures rise more than proportionally to per capita income (particularly for low-income countries). 2/

As was expected, military expenditures are positively correlated with central government expenditures. The estimated coefficient of 0.75 is significantly less than unity. This implies a slightly less than proportional relationship between the budget and military expenditures. When budgetary appropriations rise, military expenditures tend to increase at a slightly lower rate, and vice versa.

The coefficients for the year dummy variables indicate that there was a decrease in military expenditures in the 1980s relative to the 1970s, as is found in Hewitt (1991).

The results related to the financial variables confirm that they have a significant impact on appropriations to the military. The heavily indebted countries spent less on the military in the 1970s and decreased their expenditures further in the 1980s relative to the average. The small low-income economies spent significantly less on the military. The net flow of public and publicly guaranteed external financing, PGFF, is positively correlated with military expenditure.

The interpretation of the coefficients on the financial variables implies that economic assistance to developing nations promotes

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1/ The elasticity is calculated by taking the derivative with respect to GDP, which yields 0.23 - 0.015ln(GDP), and substituting for the minimum and maximum values of GDP. The maximum, minimum, and mean values for the variables are listed in Appendix Table 7.

2/ The coefficient on population reverses sign and is significant in the single-equation formulation (Appendix Table 8). Thus, in the simultaneous-equations model, the direct effect of population is positive though insignificant. The indirect effect through the development index, which incorporates the inverse of the population, is implicitly negative and significant (see below). Not surprisingly, the reduced-form estimation indicates an overall negative association. Countries with larger populations tend to spend less on the military, holding other factors constant.

increased military expenditures. The receipt of economic assistance induces governments to allocate more resources to the military. However, this conclusion must be viewed as tentative because the exact coverage of PGFF is somewhat unclear. It is difficult to determine the extent to which financing for military imports is included in these figures. However, in all likelihood, a high proportion of military-related financing is omitted from the accounts of developing countries. It is common practice to keep these expenditures off-budget. However, another weakness in the econometric specification herein is that no variable for economic grants is incorporated into the analysis. 1/

Other econometric studies that have tested for this effect have found support for the hypothesis that economic assistance causes military expenditures to rise, for example, Looney (1986). Cashel-Cordo and Craig (1990) examined the effect of different types of foreign aid and produced mixed results that contradict these findings. 2/

b. Political and geographic variables

The political variables produced an interesting pattern. Recall that the benchmark is a multiparty democracy, not recently engaged in either an international war or a civil war (see Section IV.1). The positive and significant coefficients associated with the these variables indicate tendencies to spend more on the military, relative to the benchmark. As expected, the highest coefficient is on international war and the second highest is on civil war. Among the other variables, the order of importance is monarchy, military government, socialist government, and "other" (which consists of one-party states or highly unstable democracies). This order is not altered when the indirect effects are considered (see below).

The geographic variables included in the estimation equation confirmed prior expectations. Land area, land borders, and coastal borders all had positive coefficients; additionally, the coastal borders coefficient was lower than the land borders coefficient. This was

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1/ The World Bank data on economic grant receipts of developing nations cover only 1980 to the present.

2/ They find that aid from multilateral development banks, including the World Bank, has a weak positive effect on both central government expenditures and military expenditures. In contrast, IMF aid in the form of tranche credit and the compensatory financing facility has a negative effect on both. However, SAF and ESAF assistance is found to induce lower central government expenditures but, surprisingly, not to decrease military expenditures. The effect of bilateral aid on both government expenditures and military expenditures was insignificant. In total it is hard to interpret these paradoxical results. Furthermore, because the coverage and specification are quite distinct from those in the present study, the results are not comparable.

expected because coastal borders provide natural protection, and therefore, less military expenditure is needed to defend them.

c. Determinants of central government expenditure

In the second equation in Table 2, the ratio of central government expenditure to GDP is the dependent variable. The results from this equation should be interpreted cautiously because the model used in this paper was not designed to explain fully the complicated process of choosing the central government budget. The central government equation is incorporated to assist in analyzing the determination of military expenditures; it includes several instrumental variables that allow an estimate of CGE/GDP that can be incorporated into the military expenditure equation. The instruments are the development index and the form of government dummy variables. The pattern observed in the year dummy variables indicates a strong likelihood of omitted variables. 1/

In the central government expenditures equation, the development index has a coefficient of approximately 0.5. This elasticity confirms that as countries become more developed, they tend to allocate a higher ratio of resources to government expenditures. Alternatively, it could imply that government expenditure is considered a superior good.

Military expenditures have a positive and significant coefficient, as expected. The associated coefficient represents an estimate of the elasticity of central government expenditures with respect to military expenditures. Its level, 0.18, is remarkably close to the average ratio of military expenditures to CGE, 0.165 (see Hewitt (1991)). This implies that autonomous increases in military expenditures are exactly accommodated by increases in the size of the budget. 2/ The strict interpretation of this result is that other types of expenditures are virtually unaffected by these increases in military expenditures. This is, of course, an average -- it is more likely that the influence of higher military expenditures on other types of government expenditures varies from country to country. In some circumstances, where the budget constraint is not tight, increases in military spending lead to higher spending on all items. The government spends more on social programs, while simultaneously increasing military spending, in order to appease

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1/ The most obvious omitted variable is the interest costs associated with higher debt obligations (see Hewitt (1991)). However, since the level of debt is itself endogenous, incorporating this variable into the analysis requires revisions to the econometric specification that would inordinately increase the level of complexity.

2/ This is the case because the elasticity is nearly the same value as the ratio of military to central government expenditures,

$$(dCGE/CGE)/(dME/ME) = ME/CGE.$$

Thus, the absolute change in the level of CGE matches the absolute change in the level of ME,

$$dCGE/dME = 1.$$

competing interest groups. In countries where the government is financially constrained, it is more likely that the government accommodates higher military expenditures by decreasing other types of government expenditures.

The coefficients on the form of government variables indicate that socialist governments tended to have higher CGE/GDP than multiparty democracies, military governments and monarchies had smaller public sectors, while the coefficient on "other" is insignificant. These results are consistent with the predictions of the model, as well as with intuitive expectations. Socialist governments, which advocated government management of the economy, were expected to have higher levels of government expenditures. In contrast, many monarchies and military governments pursued more minimal-intervention policies with respect to economic affairs.

The direct and indirect effects of political variables in the first equation and the form of government variables in the second equation indicate the total effect of these variables on military expenditures. The positive coefficient associated with socialist governments in the central government expenditure equation means that the indirect effect reinforces the direct effect. Socialist governments tended to have higher central government expenditures and to allocate a higher proportion of the budget to the military. In contrast, the direct and indirect effects of the other forms of government worked in opposite directions. Military governments and monarchies tended to have smaller public sectors, but tended to allocate a higher share of the budget to the military; the same was true of countries in the "other" category, but the indirect effect was insignificant. In all of these cases, the direct effect dominates the indirect effect, therefore the total impact of these political variables on military expenditure remains positive and their order of importance does not shift.

The coefficients on the financial variables do not confirm all prior expectations; the coefficients on HD80 and SLIE are insignificant and the coefficient on HD70 is negative. However, the coefficient on PGFF is positive and significant, as predicted. Similar conclusions regarding the direct and indirect effects of the financial variables are of interest. The net flow of public and publicly guaranteed external financing increases military expenditures both directly and indirectly. Higher PGFF increases the overall size of the public sector, which indirectly increases military spending; additionally, higher PGFF is found to shift the mix of government expenditures toward the military. This implies that the military received a disproportionate share of economic assistance relative to other types of expenditure. 1/

1/ The fact that some bilateral donors link economic assistance with military assistance partially explains this result.

The coefficients on the year dummy variables indicate that central government expenditures were higher in the 1980s relative to the 1970s, probably because of considerably higher interest costs (Hewitt (1991)).

3. Allies and rivals

In an alternative model, a number of variables were incorporated to account for the interaction of military expenditures between allies and rivals. It is well known that some nations give a great deal of attention to the military posture of allies and rivals. Since this is not a major concern in the present paper, there will be no review of the extensive literature, nor will the relationship fully modeled. However, in order to determine how this factor may affect the model, the simultaneous equations were recalculated to incorporate a few obvious interaction variables. The results of the new regression equations are reproduced in Appendix Table 9. Since the new variables are lagged, they have no impact on the central government expenditure equation.

The seven new variables include three ally variables and four rival variables. The presumed groups of allies are the industrial countries, Eastern Europe, and the frontline Middle East Arab nations. The first two groups are assumed to be rivals, and the Middle East Arab states and Israel are assumed to be rivals. The variables are lagged by one year under the assumption that the prior year's expenditures influence current decisions. The lagged relationship avoids simultaneity bias between the military expenditures of allies and rivals.

The results are quite encouraging, all the coefficients have the expected sign, and four out of seven are significant. The significant coefficients are the Eastern European ally variable, the industrial nations rival variable, the Middle East rival variable, and the Israel rival variable. This strongly supports the hypothesis that levels of military expenditures are positively related to the expenditures of rivals, but only weakly confirms the hypothesis that military expenditures of allies are substitutes. These results should be viewed as tentative because they only superficially examine the inter-relationship between allies and rivals. The interaction is, of course, much more complicated and therefore beyond the scope of this study. The impact of these variables on the other estimated coefficients is modest -- there is no change in significance or sign.

V. Conclusions

The econometric analysis in this study is based on a more comprehensive data base than other cross-section empirical studies of the demand for military expenditures. Over two thousand observations derived from 125 countries over a 17-year span are used, while other studies tended to analyze data for a selected number of countries over a limited period of time, normally 1 year. Given the wide span of the data, one might expect that no concrete findings would emerge. The

conventional wisdom in much of the existing literature is that the decision-making process for military expenditures is country specific; instead of being determined by economic, financial, and quantifiable political variables, military expenditures were thought to be determined by political circumstances peculiar to each country.

The results of this study disprove this notion. The ability of the model to explain over 55 percent of the variance in military expenditures indicates that significant patterns do exist. Furthermore, the fact that model predictions regarding the signs of so many variables were confirmed indicates that the public choice framework is useful for analyzing cross-country determinants of military expenditure. However, there is still an unexplained residual of 45 percent, which undoubtedly reflects country-specific features related to preferences of the population, the security situation of the country, and the efficiency with which the military utilizes funds in different countries.

The geographic variables confirm the influence of cost elements in determining military expenditure. The political variables confirm that different forms of government tend to have different patterns of expenditures. Monarchies and military governments tended to have relatively modest public sectors that allocated a disproportionately large share to the military. Socialist governments tended to have very large public sectors that allocated somewhat more to the military than did multiparty democracies. The reasons for these patterns undoubtedly reflect political priorities and the ideology of the leadership. However, the reverse causality could exist. The geopolitical status of a country could influence both the type of government that takes power and the level of military expenditures.

The most important results of the study come from the coefficients on the economic and financial variables. These findings demonstrate that, on average, military expenditures are sensitive to financial constraints and economic circumstances.

Table 3. Categories of Countries

Net Creditor	Heavily Indebted Middle Income 1/	Small Low-Income Economies 2/
Iran	Argentina	Benin
Kuwait	Bolivia	Burkina Faso
Libya	Brazil	Burundi
Oman	Chile	Cameroon
Saudi Arabia	Congo	Central African Republic
Taiwan Province of China	Costa Rica	Chad
United Arab Emirates	Côte d'Ivoire	Ethiopia
	Ecuador	Ghana
	Egypt	Guinea-Bissau
	Mexico	Guyana
	Morocco	Haiti
	Nicaragua	Kenya
	Nigeria	Liberia
	Peru	Madagascar
	Philippines	Malawi
	Venezuela	Mali
		Mauritania
		Mozambique
		Myanmar
		Nepal
		Niger
		Rwanda
		Senegal
		Sierra Leone
		Somalia
		Sri Lanka
		Sudan
		Tanzania
		Togo
		Uganda
		Zaire
		Zambia

1/ Heavily indebted countries are nations with an external debt to exports ratio in excess of 3 and an external debt to GDP ratio in excess of 0.8. Nations that met these criteria which are not in the WEO list were Congo, Costa Rica, Egypt, and Nicaragua. The countries that were deleted from the WEO list were Colombia, Uruguay, and Yugoslavia.

2/ Small low-income economies consist of nations with a per capita income less than $400 in 1980 and a population less than 50 million. Bangladesh and Pakistan were eliminated from the WEO list of small low-income economies group since they rank eighth and ninth in population among the world nations.

Note: The term "country" used in this report does not in all cases refer to a territorial entity that is a state as understood by international law and practice. The term also covers some territorial entities that are not states but for which statistical data are maintained and provided internationally on a separate and independent basis.

Table 4. Summary Statistics of Political Dummy Variables
(Number of Countries in Each Category)

	1972	1973	1974	1975	1976	1977	1978	1989	1980	1981	1982	1983	1984	1985	1986	1987	1988
International war	8	8	8	8	10	10	10	10	11	11	11	11	11	11	11	11	11
Civil war	9	9	9	9	9	10	10	10	10	12	13	13	13	14	14	14	14
Socialist governments	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Military governments	35	35	35	35	34	35	35	34	34	32	31	31	31	30	30	30	30
Monarchies	8	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7
Democracies	31	31	32	32	32	32	32	32	33	32	32	32	32	33	33	33	33
Others	20	20	19	19	19	17	17	18	18	17	17	17	17	16	16	16	16

Sources: Sivard (1987), SIPRI Yearbook, Europa World Yearbook.

Table 5. Summary Statistics of Form of Government Dummy Variables
(Number of Countries in Each Category)

	1972	1973	1974	1975	1976	1977	1978	1989	1980	1981	1982	1983	1984	1985	1986	1987	1988
Socialist governments	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	15
Military governments	43	43	44	45	46	46	46	46	45	44	44	44	44	43	43	42	42
Monarchies	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Democracies	35	35	35	35	34	35	35	35	36	36	36	36	36	37	37	38	38
Others	24	24	23	22	22	21	21	21	21	21	21	21	21	21	21	21	21

Sources: Sivard (1987), Europa World Yearbook

Table 6. Military Expenditures in Proportion to GDP, 1972-88

	Averages		Variance/Mean	
	SIPRI	Adjusted SIPRI	SIPRI	Adjusted SIPRI
	(In percent of GDP)			
Algeria	2.0	3.0	0.05	0.15
Angola	17.2	29.1	0.85	0.97
Argentina	4.6	4.6	0.19	0.19
Australia	2.7	2.7	0.03	0.03
Austria	1.2	1.2	0.01	0.01
Bahrain	4.5	4.5	0.61	0.61
Bangladesh	1.4	1.6	0.09	0.07
Belgium	3.1	3.1	0.01	0.01
Benin	1.8	3.0	0.06	0.24
Bolivia	3.4	3.7	0.33	0.35
Botswana	3.4	3.6	0.15	0.20
Brazil	1.3	1.3	0.09	0.09
Bulgaria	4.3	5.3	0.10	0.17
Burkina Faso	2.6	3.2	0.19	0.30
Burundi	2.7	3.2	0.09	0.13
Cameroon	1.8	2.1	0.05	0.11
Canada	2.0	2.0	0.01	0.01
Central African Rep.	2.1	2.0	0.05	0.17
Chad	4.6	6.1	0.36	1.29
Chile	7.1	7.6	0.30	0.32
China	9.1	9.1	1.19	1.19
Colombia	1.6	1.8	0.15	0.18
Congo	3.6	4.5	0.27	0.20
Costa Rica	0.6	0.7	0.02	0.03
Cote d'Ivoire	1.1	1.4	0.01	0.04
Cuba	7.9	11.7	0.80	1.99
Cyprus	1.7	2.1	0.18	0.09
Czechoslovakia	4.6	4.9	0.00	0.01
Denmark	2.3	2.3	0.01	0.01
Dominican Republic	1.6	1.6	0.03	0.02
Ecuador	1.9	2.8	0.07	0.14
Egypt	14.8	17.6	7.20	6.51
El Salvador	2.9	3.9	0.58	1.48
Ethiopia	7.1	14.0	1.29	3.10
Fiji	0.4	0.4	0.05	0.06
Finland	1.8	1.8	0.04	0.04
France	3.9	3.9	0.00	0.00
Gabon	2.2	2.6	0.56	0.61
German Democratic Rep.	5.2	5.6	0.03	0.03
Federal Rep. of Germany	3.3	3.3	0.01	0.01
Ghana	1.0	1.1	0.21	0.21
Greece	6.3	7.1	0.12	0.16
Guatemala	1.9	2.1	0.32	0.27
Guinea-Bissau	4.2	8.3	0.50	0.76
Guyana	6.5	7.2	1.36	1.04
Haiti	1.4	1.5	0.01	0.01
Honduras	3.1	3.6	0.87	1.08
Hungary	2.6	3.3	0.10	0.04
India	3.1	3.6	0.02	0.05
Indonesia	3.8	4.0	0.22	0.21
Iran	6.3	6.1	2.10	2.18
Iraq	16.3	22.3	3.77	4.00
Ireland	1.6	1.6	0.03	0.03
Israel	19.6	27.1	1.36	2.05
Italy	2.3	2.3	0.01	0.01
Jamaica	1.0	1.0	0.10	0.10
Japan	0.9	0.9	0.00	0.00
Jordan	16.8	25.5	0.69	0.74
Kenya	2.9	3.5	0.32	0.42
Korea, South	5.1	5.9	0.08	0.07
Kuwait	5.7	5.7	0.43	0.43
Lebanon	5.2	6.0	0.88	1.29
Liberia	2.0	2.3	0.71	0.78
Libya	10.3	13.9	1.32	1.81
Luxembourg	0.9	0.9	0.02	0.02
Madagascar	2.2	2.6	0.12	0.20
Malawi	2.0	2.2	0.58	0.77
Malaysia	6.2	6.7	0.16	0.15
Mali	4.0	5.0	0.79	0.82
Mauritania	8.2	9.5	3.05	4.04
Mauritius	0.2	0.3	0.04	0.07

Table 6. Military Expenditures in Proportion to GDP, 1972-88 (concluded)

	Averages		Variance/Mean	
	SIPRI	Adjusted SIPRI	SIPRI	Adjusted SIPRI
	(In percent of GDP)			
Mexico	0.6	0.6	0.01	0.01
Morocco	4.9	6.2	0.27	0.54
Mozambique	7.6	12.6	0.16	0.61
Myanmar	3.8	6.1	0.10	1.32
Nepal	1.1	1.2	0.14	0.12
Netherlands	3.1	3.1	0.00	0.00
New Zealand	1.8	1.8	0.02	0.02
Nicaragua	9.5	12.7	10.97	14.38
Niger	0.7	0.8	0.01	0.09
Nigeria	2.6	2.8	0.60	0.46
Norway	3.1	3.1	0.01	0.01
Oman	23.2	23.2	0.74	0.74
Pakistan	6.5	6.9	0.03	0.06
Panama	1.4	1.6	0.17	0.19
Paraguay	1.4	1.6	0.05	0.03
Peru	5.2	6.1	0.54	0.53
Philippines	2.2	2.4	0.23	0.20
Poland	3.7	4.3	0.03	0.03
Portugal	4.1	4.3	0.43	0.36
Romania	1.7	2.0	0.08	0.11
Rwanda	1.7	2.0	0.02	0.08
Saudi Arabia	17.0	17.0	1.24	1.24
Senegal	2.6	2.8	0.15	0.21
Sierra Leone	0.9	1.0	0.05	0.07
Singapore	5.5	5.5	0.05	0.05
Somalia	3.5	7.3	0.52	1.23
South Africa	3.6	3.6	0.13	0.13
Spain	2.1	2.2	0.07	0.08
Sri Lanka	1.9	2.0	0.77	0.80
Sudan	2.6	3.3	0.12	0.09
Swaziland	2.1	2.2	0.14	0.12
Sweden	3.0	3.0	0.04	0.04
Switzerland	1.9	1.9	0.01	0.01
Syrian AR	14.3	22.4	0.43	0.80
Taiwan Province of China	6.4	7.1	0.07	0.07
Tanzania	4.3	5.2	0.46	0.67
Thailand	4.2	4.8	0.20	0.20
Togo	2.2	2.9	0.16	0.24
Trinidad & Tobago	1.7	1.8	0.55	0.55
Tunisia	3.5	4.0	0.99	1.15
Turkey	4.7	5.3	0.10	0.07
Uganda	2.8	3.3	0.21	0.23
U.S.S.R.	11.7	11.7	0.02	0.02
United Arab Emirates	4.6	4.6	1.81	1.81
United Kingdom	4.8	4.8	0.02	0.02
United States	5.9	5.9	0.05	0.05
Uruguay	2.6	2.8	0.12	0.14
Venezuela	2.3	2.3	0.08	0.08
Yemen, AR	9.6	13.9	2.21	4.24
Yemen, PDR	16.3	37.2	0.59	5.16
Yugoslavia	4.6	4.8	0.09	0.09
Zaire	2.8	3.7	1.05	0.95
Zambia	3.8	4.6	0.45	0.56
Zimbabwe	5.7	6.1	0.30	0.36

Sources: SIPRI, ACDA, Steinberg (1990), GFS, IFS.

Table 7. Descriptive Statistics of the Regression Variables

	Mean	Variance	Minimumn value	Maximum value
Net flow of external capital	0.0252	0.0018	-0.0491	0.8415
Real GDP in US$	9.8604	3.4620	6.1174	15.0156
Real GDP in US$ squared	100.6870	1458.3000	37.4229	225.4695
Population	2.2327	2.2618	-1.3509	6.9884
Ratio of central government expenditure to GDP	3.3123	0.2593	0.8642	4.6168
Coastline	5.1432	22.0264	-4.6052	11.4176
Land in square kilometers	5.4797	3.5055	-0.5108	10.0169
Land borders	6.4613	15.4502	-4.6052	10.0230
Heavily indebted countries, 1972-79	0.0632	0.0592	0.0000	1.0000
Heavily indebted countries, 1980-88	0.0696	0.0648	0.0000	1.0000
Small low income economies	0.2420	0.1835	0.0000	1.0000
Civil war	0.0820	0.0753	0.0000	1.0000
International war	0.0721	0.0669	0.0000	1.0000
Socialist government	0.0993	0.0895	0.0000	1.0000
Military government	0.2686	0.1966	0.0000	1.0000
Monarchy	0.0558	0.0527	0.0000	1.0000
Other	0.1402	0.1206	0.0000	1.0000

Sources: Tables 4,5 and 6, IFS, GFS, CIA World Fact Book.

Table 8. Single-Equation Econometric Estimates

Dependent variable	SIPRI Military Expenditure Ratio to GDP			Adjusted SIPRI Military Expenditure Ratio to GDP		
	Coefficient	t-ratio	Beta coefficient	Coefficient	t-ratio	Beta Coefficient
Constant	-2.751	-6.60	--	-2.798	-6.51	--
Real GDP in U.S. dollars	0.391	4.91	0.824	0.418	5.08	0.824
Real GDP in U.S. dollars square	-0.010	-2.44	-0.413	-0.013	-3.12	-0.514
Population	-0.176	-7.77	-0.299	-0.170	-7.25	-0.271
Net flow of external capital	1.207	2.88	0.057	1.520	4.98	0.091
Coastline	0.018	4.68	0.097	0.024	5.89	0.118
Land in square kilometers	0.084	6.80	0.178	0.094	7.31	0.187
Land borders	0.031	6.46	0.141	0.034	6.81	0.145
International war	1.762	25.65	0.513	1.995	27.99	0.544
Civil war	0.912	13.05	0.283	1.079	14.89	0.314
Socialist government	0.647	11.16	0.226	0.759	12.64	0.250
Military government	0.527	10.16	0.265	0.601	11.07	0.283
Monarchy	0.945	12.90	0.245	0.895	11.76	0.217
Other	0.254	4.36	0.101	0.279	4.61	0.104
Heavily indebted countries, 1972-79	-0.458	-6.84	-0.126	-0.493	-7.10	-0.126
Heavily indebted countries, 1980-88	-0.461	-7.23	-0.133	-0.485	-7.35	-0.130
1972	-0.001	-0.02	-0.000	-0.004	-0.05	-0.001
1973	0.006	0.07	0.002	0.002	0.03	0.001
1975	0.090	1.03	0.024	0.103	1.13	0.026
1976	0.146	1.66	0.039	0.177	1.94	0.044
1977	0.150	1.71	0.040	0.200	2.20	0.050
1978	0.184	2.10	0.049	0.237	2.60	0.059
1979	0.182	2.07	0.049	0.249	2.74	0.063
1980	0.199	2.26	0.054	0.270	2.95	0.068
1981	0.175	1.99	0.047	0.241	2.64	0.061
1982	0.210	2.37	0.057	0.271	2.96	0.069
1983	0.183	2.06	0.049	0.245	2.67	0.062
1984	0.157	1.76	0.042	0.227	2.46	0.057
1985	0.148	1.67	0.040	0.212	2.31	0.053
1986	0.172	1.94	0.046	0.231	2.51	0.058
1987	0.114	1.27	0.030	0.181	1.96	0.045
1988	0.085	0.93	0.022	0.118	1.25	0.028
F Statistic	45.80			52.14		
R-Squared	0.411			0.443		
Number of observations	2,063			2,066		

Table 9. Econometric Estimates With Allies and Rivals

Dependent variable	SIPRI Military expenditure to GDP			Adjested SIPRI military expenditure to GDP		
	Coefficient	T-ratio	Beta Coefficient	Coefficient	T-ratio	Beta Coefficient
Constant	-3.579	-5.71	--	-3.770	-5.74	--
Real GDP in U.S. dollars	.249	3.42	.528	.283	3.80	.563
Real GDP in U.S. dollars squared	-.008	-2.21	-.334	-.011	-3.04	-.440
Population	-.001	-.03	-.002	.006	.16	.009
Ratio of central government expenditure to GDP	.552	3.45	.320	.574	3.47	.313
Net flow of public and publicly guaranteed external capital (PGFF)	.850	2.06	.041	1.46	5.35	.088
Heavily indebted nations, 1972-79	-.359	-5.58	-.099	-.382	-5.86	-.099
Heavily indebted nations, 1980-88	-.431	-7.36	-.125	-.454	-7.62	-.123
Small low-income economies	-.178	-2.76	-.067	-.102	-2.01	-.047
International war	1.327	16.72	.391	1.503	18.41	.415
Civil war	1.061	13.79	.332	1.228	15.39	.361
Socialist government	.718	8.33	.245	.792	9.02	.253
Military government	.709	11.19	.358	.784	12.01	.371
Monarchy	.768	7.62	.201	.660	6.33	.162
Other forms of government	.435	7.20	.171	.456	7.39	.169
Land area (in square kilometers)	.063	4.78	.135	.071	5.14	.141
Land borders (in kilometers)	.030	6.44	.134	.034	7.06	.141
Coastline	.007	1.81	.039	.012	2.88	.601
Allies						
Eastern Europe	-.000007	-2.03	-.237	-.000006	-1.75	-.183
Industrial countries	-.0000008	-1.26	-.102	-.0000009	-1.47	-.106
Middle East	-.000004	-.52	-.031	-.000003	-.53	-.029
Rivals						
Eastern Europe	.000002	1.46	.132	.000001	1.12	.089
Industrial Countries	.000003	1.87	.169	.000003	2.10	.170
Middle East	.0002	3.77	.230	.0002	4.27	.244
Israel	.00002	2.13	.044	.00002	2.43	.048
1972	.050	.64	.013	.056	.70	.014
1973	.030	.38	.008	.035	.44	.009
1975	.021	.27	.006	.031	.39	.008
1976	.069	.88	.019	.090	1.11	.023
1977	.076	.97	.020	.119	1.47	.030
1978	.089	1.12	.024	.133	1.63	.033
1979	.097	1.23	.026	.143	1.76	.036
1980	.068	.85	.019	.122	1.46	.031
1981	.028	.34	.008	.073	.85	.019
1982	.053	.61	.014	.108	1.18	.027
1983	.042	.49	.011	.096	1.07	.024
1984	.013	.15	.003	.073	.82	.018
1985	.013	.16	.004	.071	.79	.018
1986	.059	.66	.016	.110	1.19	.028
1987	.005	.06	.001	.064	.71	.016
1988	-.019	-.22	-.005	.128	.14	.003
F statistic	58.50			67.43		
R-squared	.521			.554		
Number of observations	2,025			2,026		

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