**The Effects of the Security Environment on Military Expenditures: Pooled Analyses of 165 Countries, 1950-2000[1]**

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Abstract

Countries' military expenditures differ greatly across both space and time. This study examines the determinants of military spending, with particular reference to the importance of the external security environment. Using the liberal-realist model of international relations, we first estimate the probability that two countries will be involved in a fatal militarized interstate dispute. We then aggregate these ex ante estimates of the likelihood of dyadic conflict, calculating the annual joint probability that a country will be involved in a fatal dispute. This is our measure of the external threat. We then estimate the level of military spending by country and year as a function of the security environment, arms races with foes and the defense expenditures of friendly countries, states' involvement in actual military conflict, economic output, and various other political variables. In analyses of a panel of 165 countries, 1950 to 2000, we find that the security environment is a powerful determinant of military spending. Indeed, our prospectively measured estimate of the external threat is more influential than any of several influences known only ex post. Our best estimate is that a one percentage point rise in the probability of a fatal dispute leads to a 3 percent increase in military spending.

[1] We thank participants in workshops at the Department of Political Science, Stanford University; the Conflict and Cooperation Conference, Northwestern University; and the 2009 NBER Summer Institute on Economics of National Security for helpful comments. All data and computations will be provided on a website. We are grateful for the research assistance of Dr. Xi Chen of Yale University.

Research on the causes of war has advanced rapidly over the past fifteen years through the analysis of pairs of states observed through time. Pooled dyadic time series allow researchers to address a question of central interest to scholars, policy makers, and citizens alike: who is likely to fight whom? Here we use information about who may fight to address another important question: why are some states heavily armed? Countries vary enormously in the resources they devote to the military, with Costa Rica at one end and large powers facing many perceived external threats at the other; but great differences are evident even among states that appear similar in resources and geopolitical position.

We undertake two tasks, using an almost complete sample of countries over the second half of the twentieth century. First, we measure the threat in countries' security environments using the predictions of the dyadic liberal-realist model (LRM) of interstate conflict aggregated to the state level. This model incorporates elements from two major schools of international relations: the liberal, in which states' political regimes and their economic relations influence the likelihood they will become involved in a militarized dispute, and the realist, with its emphasis on the absolute and relative power of nations, their alliances, and geographic considerations.

Second, we use these annual estimates of countries' external threats to explain their military expenditures. Economic models of military spending typically treat a state's expenditures as an optimization problem, with a demand function to maximize external security from a threat (typically measured by rivals' military spending), subject to a budget constraint and other factors, expenditures of allies, and the spillover of private goods such as internal security. These influences vary greatly both across countries and over time; but military spending also may exhibit a high degree of inertia from external processes (arms races or the experience of violent conflict) or from internal influences, such as organizational inertia or a "military-industrial complex." The major innovation in our study is to develop and use new measures of the external threat in explaining defense expenditures; these are measured ex post by the actual frequency of disputes and the fatality rate of actual conflicts but also ex ante as the predicted probability of a militarized dispute using the LRM. This is the first time that a study has used a broad prospectively measured gauge of the external security environment as an explanatory variable of defense expenditures.

That the security environment should influence national military spending is hardly surprising, but the ex ante probability of a militarized interstate dispute (MID) is an unexpectedly powerful determinant. A one percentage point increase in the aggregate probability of a MID, as predicted by the LRM, leads to a three percent increase in a country's military expenditures. Indeed, the ex ante probability of conflict proves to be a greater, more robust determinant of military spending than are our ex post measures of actual conflict. A country's size, measured by its gross domestic product (GDP), is also a powerful determinant of its military spending. Additionally, we find significant inertia in national expenditures, with spending responding with sizable lags to changes in output or the level of threat.

In addition to explaining important determinants of defense spending, our research provides a valuable "external" test (Lakotos 1978) of the widely accepted liberal-realist model of interstate conflict by demonstrating its ability to generate important predictions about additional phenomena: national military expenditures.

## The Liberal-Realist Model (LRM) of Dyadic Interstate Conflict

We begin with a brief discussion of the determinants of interstate conflict that are incorporated into the liberal-realist model. We then consider some of the statistical issues that arise in estimating this regression equation. In subsequent sections, we discuss factors that affect national military expenditures and then estimate several models to clarify the importance of these various influences, focusing on the security environment as measured by the LRM.

Research on the causes of war has increasingly relied upon pooled dyadic time series. Under this approach, the unit of analysis is the state of relations between two countries in a given year (a "dyad-year"). The occurrence of a violent dispute between the two countries is taken to be a function of political, economic, and military characteristics of the two countries individually along with certain dyadic features such as trade, alliances, and geography. Such an analysis would provide, for example, estimates of the probability of a conflict between the United States and Iraq in a particular year as a function of a set of national and dyadic characteristics. Analyses of pooled dyad-year data can include not only political characteristics of the states but also elements of national culture or even attributes of individual leaders. They can easily accommodate inherently relational variables—for example, the balance of power—that are difficult to incorporate in the time series of individual states. At the other end of the spectrum, dyadic analyses can also include features of the international system, such as the distribution of national capabilities among the major powers or the concentration of power in the hands of the largest state.

Our dyadic model of interstate conflict includes elements from both the liberal (or Kantian) and the realist schools and is the outgrowth of early work by Solomon Polachek (1980) and Stuart Bremer (1992). To represent liberal theory, we include measures of the political character of the two states, assessed along the autocracy-democracy continuum, and the degree to which the states are economically interdependent, as represented by the economic importance of bilateral trade. In accord with realist thought, we add a measure of the dyadic balance of power; a measure of states' ability to project their military capabilities; an indicator of a defense pact, non-aggression treaty, entente, or other security agreement; and variables that capture states' geographic proximity. We also consider each dyad's historical experience of violence, measured by the years of peace since its last fatal militarized interstate dispute (MID); however, this variable introduces serious statistical problems, as we show.

We write the standard LRM model as follows:

(1) $$p_{i,j}^{fatal}(t) = f[Polity(t), Economic(t), Geography(t), PeaceYears_{i,j}(t), \ldots] + \varepsilon_{i,j}(t)$$

Here $p_{i,j}^{fatal}(t)$ is the dyad-year probability of a fatal militarized dispute, one involving at least one combatant's death, between states *i* and *j* in year *t*. This variable equals one when a dispute was ongoing and zero when there was no dispute. The explanatory variables in equation (1) have been developed in the literature on predicting the onset of interstate conflict. We capture the effect of states' political regimes using the lower and higher democracy scores in a dyad (Oneal and Russett 1997). Economic interdependence is represented by the lower bilateral trade-to-GDP ratio, which represents the degree to which the less constrained state is free to use force. The influence of the power of the states is expressed in the balance of national capabilities of military significance, measured by the relative size of the two countries ( $GDP_{large} / GDP_{small} + GDP_{large}$ ); this represents the naïve probability of the larger state winning a military contest.[2] We account for the ability of the more powerful state to project its military capabilities using the logarithm of its GDP in year t; this variable is normalized by world gross product to remove the long-term trend.

To represent the influence of geography, we include an indicator of contiguity and the logarithm of the capital-to-capital distance separating the two states. *System Size* is a correction for variation over time in the number of states in the international system. $PeaceYears_{i,j}(t)$ is a term reflecting the history of conflict between countries *i* and *j* designed to correct for temporal dependence in the dyadic time series. In earlier studies, the peace-years variable was introduced along with three splines to capture the effect of lagged values of that variable, but we omit the splines to simplify the presentation. $\varepsilon_{i,j}(t)$ is a random error term. Russett and Oneal (2001), Oneal and Russett (2005) and Hegre, Oneal, and Russett (2010) provide details regarding the definitions of these variables and the sources of our data.

*Estimates of the onset of militarized interstate disputes*

In the first two columns of Table 1, we report estimates of the standard liberal-realist model of the onset of a fatal militarized interstate dispute, first for the years 1885-2000 and then for the post-World War II period, 1950 – 2000. The pooled time series of over 12,000 pairs of states are analyzed using logistic regression analysis with a panel estimator in STATA 10.1. There are 435,632 and 405,528 observations (dyad-years), respectively.[3] Fixed country or time effects are not included, and the robust standard errors are adjusted for clustering by dyad. We consider only onsets, the first year of a

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[2] Trade and GDP data are Gleditsch's (2002) current version found at http://privatewww.essex.ac.uk/~ksg/exptradegdp.html

[3] Our analysis omits all states with population below 500,000 as well as Kiribati, Tuvalu, and Tonga. These countries are relatively insignificant in the military context and have missing data in the Correlates of War database.

dispute, and exclude subsequent years of an on-going dispute as recommended by Beck, Katz, and Tucker (1998).

The results of our analyses of the two sets of cases are similar: (1) Two democracies are very peaceful, two autocracies less so, and mixed pairs fight a lot. (2) Economic interdependence reduces conflict. (3) A preponderance of power increases the prospects for peace, while a balance of capabilities is dangerous. (4) Large powers are prone to fight, presumably because their interests are widespread and their capabilities for defending and promoting them are substantial. (5) An alliance reduces the likelihood of military conflict, though, surprisingly, good economic relations provide a greater assurance of peace than does an explicit security agreement. (6) Conflict is much more likely for states that are geographically proximate. As a result of variability in these influences, the predicted values derived from the LRM vary substantially across dyads.

There are, of course, many unanswered questions in research using the liberal-realist model. All the variables included in the LRM tend to vary slowly over time, so these analyses do much better in identifying the "dangerous dyads" than when those states will actually fight (Glick and Taylor forthcoming). The model captures the permissive rather than the proximate causes of interstate conflict (Waltz 1954). Research on civil wars suffers from the same deficiency (Sambanis 2004). In this respect, social scientists investigating the causes of war are like geophysicists predicting earthquakes. Scientists can identify earthquake-prone regions with confidence; they are much less successful in predicting the timing of particular events. Similarly, the likelihood of conflict for some states is far lower than for others, but we cannot predict when it will break out, even for the violence-prone pairs.

*Estimates including all years of conflict*

The standard approach to estimating the LRM is to use only the onset of a dispute and omit observations that are continuations of the same conflict. For example, the United States and North Vietnam fought from 1963 through 1972. Using the standard approach, the first year (1963) of conflict would be included but all remaining years of that conflict would be dropped. While this measure is appropriate for examining the transition from peace to conflict, it is inappropriate here because it does not capture the severity of the external military threat. If states anticipate the possibility of becoming involved in a protracted war, they would be expected to spend more on the military than if only brief skirmishes were anticipated. We therefore use a "continuation sample," in which all years of all disputes are included, when assessing countries' external threats and creating our measure of their security environments.

Including all years of disputes leads, however, to biased estimates of the regression coefficients if we include "peace-years" in equation (1). The difficulty is easily shown. Suppose there is actually no relationship between the years a pair of states has been at peace and the occurrence of a militarized dispute. Then, regressing onsets on the years of peace would yield a coefficient of zero. If we analyze the continuation sample, on the other hand, roughly half the years coded one represent the second, third, or later years of a dispute. After the first year of each MID, the peace-years variable is set to zero. For the continuation years, therefore, there will be an inverse relationship between the years of peace and the probability of conflict. This inverse relationship is completely uninformative. It is simply an artifact of the construction of the peace-years variable.

An example using the United States and North Korea over the period 1950-2000 will illustrate the problem. Of the 51 years, there are 35 years in the non-continuation sample, with 11 years of conflict and 24 years of peace. If we use only the 35 years in the non-continuation sample, a simple logistic regression of the probability of a MID has a coefficient on peace-years of -0.149 ($\pm$ 0.12). However, in this dyadic time series there are 22 years of continued disputes. If we include all 51 years in the analysis, the estimated coefficient falls to -0.340 ($\pm$ 0.13). The lower coefficient in the continuation sample represents a downward bias arising from the fact that continuations of disputes are always associated with a zero value of peace-years.

Thus, when we use the continuation sample (i.e., all years for each dyad), to obtain unbiased estimates we need either to omit the peace-years variable or to create an instrumental variable (IV) for it. If we solve equation (1) using past values of the $p_{i,j}^{fatal}(t)$ variable, we obtain as appropriate instruments the lagged liberal and realist variables (i.e., lags of the states' polity scores, the dyadic balance of power, contiguity, etc.). We call the IV estimate of peace-years "PY-hat."

We also must take into consideration the possibility that conflict will have reciprocal influences on the other independent variables in equation (1). The onset of a serious dispute, for example, is expected to affect bilateral trade adversely; and the structure of government may change over the course of a major war. [4] We address this potential problem by constructing a set of "historical instrumental variables," for each of the independent variables. These are equal to their actual values during peacetime and to their last peacetime values in a period of conflict. These historical IVs will be shown to be unnecessary so need not be discussed in detail.

In Table 2, we report five sets of estimated coefficients for equation (1) with the continuation sample for the years 1950-2000. Column E, for reference purposes, gives the results of using the actual years of peace in the specification from Table 1. Thus, the results in column E correspond to the first column of Table 1. The only difference is that the continuation sample is employed in Table 2 and data regarding only the onset of conflicts (the non-continuation sample) are used in Table 1. Columns A through D show

[4] Dyadic conflict reduces trade and inhibits transitions to democracy, but the reciprocal effects of trade and democracy on peace are robust (Hegre, Oneal, and Russett 2010, Reiter 2001).

four different specifications for analyzing the continuation sample with IV variables included or excluded. Columns A and B report coefficients for the same equation shown in Table 1 with and without PY-hat and with other independent variables set at their actual values. In columns C and D, historical IVs are substituted for the explanatory variables of the LRM.

Begin by comparing column E in Table 2 with the IV versions in columns A and C and the estimated coefficient for PY in the first column of Table 1. The coefficient in E is much more negative than the other estimates, indicating that the bias discussed earlier is indeed present when analyzing the continuation sample. (The bias is even greater if we use the spline function as is common, instead of the simple count of the years of peace.) Note also that the peace-years IV is statistically insignificant in column A and marginally significant in C. This suggests that peace-years is significant in column E because it is correlated with additional years of conflict , not because it contains information about prior values of the other independent variables.

Figure 1 shows the stability of the estimated coefficients. It confirms that major differences appear between E and the other estimators for several of the independent variables. There are no systematic differences in the estimated coefficients across equations A through D. Some differences are due to different samples. Using IVs reduces the sample size.

In our analyses of national military expenditures, we focus primarily on the specification in column B of Table 2. It is our preferred version for the following reasons. First, it is clearly desirable either to omit peace years or to use PY-hat, so that removes equation E from contention. Second, the IV for peace years is statistically insignificant at the .05 level in columns A and C, suggesting that those specifications are not superior. Third, there are no significant differences between the results in column D where the historical IVs are used and the analysis with the actual variables in B, but the latter are more precisely estimated. Apparently, the reciprocal effects of conflict on the theoretical variables of interest are a less important source of bias than is the peace-years correction. Finally, equation B has the maximum sample size. This means that fewer imputations need to be made in constructing our estimates of the security environment for inclusion in our analyses of national military expenditures.

## Estimating the Annual Probability of a Fatal Dispute for Each Country

We now break new ground by using the liberal-realist model to calculate prospectively a summary measure of the threat each country faces in its external security environment. If the LRM captures the probability of serious interstate conflict, we should be able to use its predictions to help explain differences in military spending.

The basic approach is to convert the dyad-year estimates of the probability of a fatal dispute from equation (1) into state-year probabilities suitable for inclusion in a model of military expenditures. We do this by calculating the annual probability that a state will be involved in a fatal dispute with at least one other country, using the standard calculation for a joint probability from the individual components:

(2) $$\hat{p}_i^{fatal}(t) = 1 - \left\{ \left(1 - \hat{p}_{i,1}^{fatal}(t)\right) \times \left(1 - \hat{p}_{i,2}^{fatal}(t)\right) \times \cdots \times \left(1 - \hat{p}_{i,n}^{fatal}(t)\right) \right\}$$

In equation (2), $\hat{p}_i^{fatal}(t)$ is the state-year probability of at least one fatal MID for state *i* in year *t*, and $\hat{p}_{i,j}^{fatal}(t)$ is the estimated dyad-year probability of a dispute between states *i* and *j* from the LRM in equation (1). We call $\hat{p}_i^{fatal}(t)$ our "*p-hat*" estimates, indicating that it is the predicted probability of a dispute.

We show our ex ante estimates of the annual probability of a fatal dispute for eight representative countries in Figure 2. "*Phat B"* is our preferred specification B from Table 2. "*Phat E"* is the specification in column E with actual peace years and the continuation sample. "*Phat F"* is derived from the first column of Table 1, where peace years were used with the non-continuation sample. An on-line appendix will provide a detailed list of countries and their average *p-hat* estimates.

The graphs show the severity of the external threat of conflict faced by each country from 1950 through 2000. Differences in our *Phat B* variable, cross-nationally and through time, are purely the result of the predictors derived from liberal and realist theories; they do not include any country- or year-fixed effects. As can be seen by examining the left-hand scale, there are major differences between high-conflict countries like the United States, the USSR/Russia, China, and Israel and low-conflict countries such as Canada, South Africa or New Zealand. For all countries except China, the end of the Cold War brought a significant decline in the probability of a dispute. This is surely the most important "peace dividend" derived from the unexpected end of that dangerous period.

The problem with using the actual years of peace in estimating *p-hat* with the continuation sample is again evident in Figure 2. The resulting time series *(Phat E)* move more erratically and are strongly influenced by the actual timing of disputes, not just their theoretical determinants. Leaving those estimates aside (as clearly biased), the other measures are highly correlated. The average correlation coefficient among the *p-hat* variants A, B, C, and D is 0.965 for all countries and 0.958 for the largest 40 countries.

## Explaining National Military Expenditures

We now turn to the principal focus of this paper: estimating the impact of the security environment on national military expenditures. A vast literature – both statistical and historical – considers the determinants of military spending. To our knowledge, however, no empirical study in international relations incorporates a comprehensive, ex ante measure of the external security environment of the kind we use here. Studies that include a measure of external threat usually proxy that variable with ex post data on the military spending of foes.

To clarify the significance of the empirical analyses presented in the next section, it is useful to distinguish normative from positive theories of military expenditures. In the normative approach, military spending provides a national public good (with transnational spillovers). Nations provide their citizens with security from external threats by allocating resources to the armed forces. Expenditures are, of course, limited by the size of the national economy. A nation's security environment is determined primarily by "objective" threats of military conflict and the cost of any ongoing militarized disputes. We are particularly interested in the influence of the security environment as represented by the LRM.

The positive approach emphasizes various other elements in explaining military spending: the political power of the "military-industrial complex," bureaucratic inertia, self-perpetuating arms races, and domestic politics (Russett 1970). We combine the two approaches to some degree, so our results shed light on their relative importance. Primarily, however, we are interested in how objective circumstances influence national defense expenditures. That interpretation fits with the characterization, common among economists, of military expenditures as an optimization problem.[5]

Table 3 shows the most and least conflict-prone countries in our sample, along with the average of their annual military expenditure-to-GDP ratios, 1950-2000.[6] The difference in the security environments between the two groups is striking, and it is clear that the external threat does influence national military expenditures. The four least threatened countries spend on average only 1.8% of GDP on their armed forces; the four that are most endangered spend four times as much, 5.7%. There is, however, considerable variability within the top group, indicating that other factors importantly influence military spending.

## Empirical Estimates of the Determinants of Military Expenditures: Specification

Our analyses cover the period 1950 to 2000. This is appropriate because the international system was relatively stable, although there were certainly significant changes, particularly the end of the Cold War. We exclude the immediate aftermath of World War II because of the turmoil involved in the demobilization of the victors and the vanquished alike and the shortage of data for these years. We stop in 2000 because some data are unavailable beyond that. We report results for two samples: 165 countries, for which we have 6607 observations; and the 40 countries with the largest

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[5] See, for example, Sandler and Hartley (1995, Chapter 2) and Smith (1995).

[6] Data are for states that gained independence during the period begin after 1950. Very small countries such as Singapore and Fiji have been excluded.

GDPs in 1980, with 1906 observations. (Note that some of the countries are successor states to countries that have fissioned, e.g., Ukraine from the USSR.)

Though we focus on the impact of the threat environment on military spending, we also consider several other potentially important influences. The most important is, of course, the size of a nation's economy, as measured by GDP. Additional variables fall into four categories.

*Arms races and alliances.* The first set of ex post geopolitical variables captures the effects of arms races with adversaries and the expenditures of allies. The contemporaneous expenditures of potentially hostile powers may be taken by national leaders as evidence of a heightened threat that necessitates a greater commitment of resources to the military. The expenditures by adversaries has been the most common way of measuring external threats in previous research and has long been modeled as an action-reaction cycle.[7] Alliances and informal international agreements may carry a commitment for support in particular circumstances, which can also influence a nation's expenditures on the military.[8]

Consequently, we constructed two measures of the military expenditures of other states. One is the sum of the military spending of "friends" in a year. The other is the military spending of potential "foes" in a year. We identified a state's friends and its foes using Signorino and Ritter's (1999) statistical measure (S) of the similarity of two states' alliance portfolios. Following Bueno de Mesquita (1981), we assume in constructing these indices that countries with the same allies (and non-allies) have similar or complementary foreign policies and security interests.

For each country, we ranked all other states in each year according to the similarity of their alliance portfolios using Signorino's *S*. States above the median were assumed to be friends; all states with *S* below the median were considered potential foes. We then summed the military expenditures of friends to obtain our measure of the spending of allies and other friendly nations. The variable for the military expenditures of foes was constructed similarly. These two measures are designed to capture the

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[7] See Rapoport (1957) on early arms race analyses traceable to Lewis Frye Richardson, primarily about how arms races may cause wars; see Sandler and Hartley (1995, Chapter 4) and Brito and Intriligator (1995) for more recent work. Dunne and Smith (2007) provide a good discussion of panel and cross-sectional models.

[8] The canonical reference on collective action is Olson and Zeckhauser (1966). In an alliance, large states are expected to spend disproportionately on the public good and smaller ones "free-ride". The predicted net effect for the alliance as a whole is suboptimal spending. More recently, see Murdoch (1995); Sandler and Hartley (1995), Chapter 2; Murdoch and Sandler (1995); Oneal and Diehl (1994); Oneal and Whatley (1996); and the articles reproduced as chs. 22-26 in Hartley and Sandler, eds. (2001). The "friends" variable does not completely capture issues raised by the presence of alliances, but a detailed treatment is beyond our scope here.

influence of other states' contemporaneous military expenditures. In the regression analysis, we take the logarithm of the spending of friends and foes to put them on the same scale as our dependent variable.

In addition to capturing the influence of alliance commitments for coordinated expenditures with friends and the consequences of arms races with potential foes, these two measures provide a valuable control for the transmission of military conflict through these channels. A state may be required or consider it prudent to spend more money on its armed forces when either a friendly country or a hostile power is involved in a military conflict, even if it is not immediately drawn into the fighting.

*Actual conflict.* We address the influence of actual, ongoing conflict on military expenditures using two variables. The first of these additional ex post measures is the incidence rate of fatal disputes. We started by calculating the fraction of a state's dyadic relations in each year that were marked by a fatal MID, this being the total number of state *i*'s dyadic interstate disputes $\sum_{j=1}^{n} p_{i,j}^{fatal}(t)$, divided by *n,* the number of states *j* in year *t*. We then constructed an index of the frequency of actual fatal disputes as follows:

$$p\text{–}actual_i(t) = 1 - \left(1 - \left(\sum_{j=1}^{n} p_{i,j}^{fatal}(t) \Big/ n\right)\right)^n$$

Our ex post variable *p-actual* is constructed so that it has the same units as our prospectively measured *p-hat* in equation (2) ; therefore, the two coefficients estimated in the analyses below are directly comparable.[9] Naturally, we expect that states that experience a higher incidence of fatal militarized disputes will spend more on their armed forces.

In addition to the number of disputes in which a country is involved, national military expenditures should reflect the intensity of those conflicts. Therefore, our second gauge of actual conflict is the number of deaths a country's combatants suffered in conflicts with all other states in a year, normalized by the population of the country.[10]

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[9] A few analysts (notably Goldsmith 2003) have used the incidence of wars, but not the much more frequent MIDs. We use fatal MIDs to tap the effect on expenditures of a wide range of interstate conflicts. We also ran tests with the predicted probability of a war and substituted a binary indicator of whether state *i* experienced a fatal dispute with any state in year t. The results were consistent with those we report in the tables.
[10] Fordham and Walker (2005) use total battle deaths in wars, but their data are not annual estimates and do not include MIDs below the threshold of 1000 combatant fatalities. We use a newly compiled dyad-year dataset of fatalities (Pleschinger and Russett 2008).

We expect that states will spend more in years when they experience a relatively large number of fatalities. In short, military expenditures are thought to be a function of the number and intensity of interstate disputes a country experiences in the course of a year.

It is important to emphasize that *p-hat* (the state-year estimates of threat we derive from the LRM) is a prospective measure of the dangers in a country's security environment. It should capture the anticipated economic requirements for fielding a military that is adequate to support a state's objectives and policies. States may favor the status quo, or be revisionist in their relations with other countries, or combine these objectives. When states are conservative and seek to maintain the status quo, *p-hat* is a better measure of the anticipated cost of deterring aggression than is the cost of actually defending territory. States may seek to modify the status quo and use their military capabilities to promote their interests, either by means of coercive diplomacy or by actual force of arms (George 1991; Jackson and Morelli 2008). States should prefer coercive diplomacy, just as they prefer deterrence, because the cost—in human life certainly—is generally lower. In explaining national military expenditures, then, we need to consider both the risk of conflict that nations anticipate and the costs they actually incur when deterrence fails or coercive diplomacy proves inadequate.

In sum, we expect national military expenditures to be a function of policy makers' ex ante estimates of the armed forces necessary for their nations' foreign policies, given the environment in which they expect to operate. They will normally seek to deter adversaries from resorting to military force and prefer to promote their interests by coercive diplomacy; but states are not always successful in achieving their objectives merely by the threat or show of force. As Engels observed, battle is to power what cash is to credit. Sometimes deterrence fails, and the military must defend the country or its strategic interests; or states may chose to force compliance with their demands if threats and demonstrations are insufficient. Thus, national military expenditures should reflect both ex ante and ex post influences.

*Democracy.* A tradition of liberal thought back to Kant suggests that popular opinion will resist the diversion of resources to military preparations and away from private consumption or other collective goods like public health and education. Citizens in democratic countries may also fear that a strong military establishment may suppress civil liberties. A contemporary version of the theory argues that, in states governed by small coalitions, autocrats will be able to extract private goods from rents associated with the successful threat or use of military force internationally and impose much of the cost on the general population. Hence autocracies should spend proportionately more on the military (Bueno de Mesquita et al. 2004; Fordham and Walker 2005; Goldsmith 2003). [11]

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[11] Democracies may be able to spend more in wartime (Bueno de Mesquita et al. 2004). For a different rationale for the lower expenditures of democratic countries, see Garfinkle (1994).

*Bureaucratic or organizational inertia.* Finally, military spending often has great inertia and may react slowly to geopolitics, especially to the disappearance of great threats. For example, after the end of the Cold War, military spending in most countries declined relatively slowly. There may be many reasons for this, including the putative lobbying power of vested interests (what Eisenhower called the "military-industrial complex," for example), uncertainty regarding the permanence of change, and the difficulties of dismantling a system with a large overhead.

In the following estimates, we anticipate a partial adjustment of military spending to the desired level. Assume that the steady-state level of desired military spending is $M^*(t)$. We expect actual spending to adjust to the desired level by the process $\Delta M(t) = \lambda[M^*(t) - M(t-1)]$. This specification has the disadvantage that spending adjusts at the same rate to changes in all determining variables, but the advantage of parsimony is a powerful one. One issue that arises, however is bias due to autocorrelated errors. We take steps to correct for this below.

Putting all the influences on national military expenditures together, we get the following full specification:

$$(2) \qquad milex_i(t) = f\begin{pmatrix} \hat{p}_i^{fatal}(t), ln[real\,GDP_i(t)]\,,\, fatal\text{-}rate_i(t), fatalities_i(t), \\ ln[milex\text{-}friends_i(t)], ln[milex\text{-}foes_i(t)], milex_i(t-1) \end{pmatrix} + u_i(t)$$

It is important to acknowledge that our measures of the external security environment are based primarily on interstate relations. Consequently, threats from non-state actors (e.g., terrorists) unallied with national governments will have little impact. This is less problematic for the period 1950-2000 than subsequently.

<u>Empirical Estimates of the Determinants of Military Expenditures: Results</u>

To gauge the importance of the security environment, we start with a visual examination of Figure 3. The bivariate scatter plot shows the mean probability of conflict as assessed by the LRM and the mean ratio of military spending to GDP for each country, 1950-2000. Both of the economic variables are measured in constant 2000 dollars calculated with purchasing power parities.[12] We show three groups of countries:

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[12] Cross-national estimates of military expenditure are subject to error (Lebovic 1998, Smith 1995, Dunn and Smith 2007). Comparability is greatest for democracies and developed economies. Some estimates may exhibit inertia due to analysts' simply extrapolating from initial estimates. After close study of many sources we settled on the military expenditure component of the Correlates of War dataset on national material capabilities (http://www.correlatesofwar.org/) for 1950-1987, but found the Stockholm International Peace Research Institute data (available only for subsequent

the largest 20 by GDP as filled circles, the second 20 by GDP as large open squares, and the balance of smaller countries as small triangles. There is a positive relationship between the two variables, with a correlation of 0.37. The character of the security environment does influence national military expenditures, but clearly other forces are at work. Our online appendix will give the average ratio of military spending to GDP for our state-year sample as well as the mean probability of a fatal dispute.

Table 4 begins with the simplest specification of equation (2) using the means of the variables for each country. We estimate the effect of the security environment *(p-hat)* on the logarithm of military expenditures, controlling only for a country's economic size. We calculated *p-hat* using the specification in column B of Table 2. The semi-elasticity of military spending with respect to the probability of a dispute is 3.20 ($\pm$ 0.63). This is slightly larger than the country-year results we report next, but it is a useful point of departure.

Table 5 reports the estimated coefficients from four pooled analysis of panel data for 165 countries, 1950-2000, for the simple specification that includes only *p-hat*, our prospective measure of the security environment, and GDP. We use the panel estimators in EViews 6.0; neither time nor fixed country effects are included. The first row shows the analysis of pooled data with no inertial effect but with a correction for autocorrelated errors. The second row accounts for inertia with a lagged dependent variable (LDV) and also includes a correction for an AR(1) process.

Use of a lagged dependent variable when there is autocorrelation in the error term introduces bias in the estimated coefficients. We address this problem in the third and fourth rows of Table 5 using an instrument for the LDV. Solving for military spending in the partial-adjustment model shows that it is a function of current and past values of GDP, the security environment, and other independent variables. We therefore used lags of the independent variables as instruments and exclude additional lagged dependent variables in all runs. We found no improvement in the fit for the IV after two lags, so we limit our IV to that number. We estimate the equation without and with an AR correction (rows 3 and 4).[13]

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years, at http://www.sipri.org/contents/milap/milex/mex_data_index.html) to be more plausible and better documented. The two series are nevertheless highly correlated. We extended the SIPRI data backwards by regressing on COW's estimates. We then converted the data to PPP-based estimates. Data for China and USSR/Russia are notably controversial. COW showed a very big drop in Chinese military spending in 1985 continuing into 1988. As that conflicts with all other reports, we raised our estimate to be consistent with SIPRI's. A similar drop in SIPRI's data for Russia/USSR from 1988 to 1991 is consistent with other estimates and with the demise of the Soviet Union.

[13] We reproduced the results for rows 1 and 2 of Tables 3 and 4 using STATA 10.1, but there is no estimator readily available in STATA for the analyses in rows 3 and 4.

We prefer the specification in row 3, but both 3 and 4 have several important features. First, it is apparent that the estimated coefficient (0.956) of the LDV in row 2 is badly biased. In row 2, the lagged value of military expenditures accounts almost completely for current military spending. Using the instrumented variable in rows 3 and 4 reduces its coefficient substantially. The estimated coefficient of the LDV is important because it is λ in the adjustment equation described above; and (1 – λ) is used to calculate the long-run impacts of our independent variables. Second, the coefficient on *p-hat* (and GDP) is much larger with the IV estimator than in the OLS regressions. The biased estimator is reducing the apparent impact of each of the theoretical variables on military spending. We also show in the column "Milex unit root" the difference between the coefficient on the LDV (λ) and unity, along with its standard error. While the coefficient in row 2 is significantly different from 1.0 statistically; it is uncomfortably close, whereas the coefficients in rows 3 and 4 are well below that value.

The last two columns of Table 5 show the semi-elasticities of military spending with respect to the external threat for each specification, i.e., the percentage change in military spending of a unit change in the probability of a fatal MID. The short-run semi-elasticity is the estimated coefficient of *p-hat*; in our preferred specification it is around 1.0. The long-run semi-elasticity, calculated as the short-run semi-elasticity divided by (1 – λ), is about 3.0, as seen in the last column of the table. The t-statistics on the *p-hat*s are high by conventional standards. For example, in equation 3 the t-statistic on the short-run elasticity is 6.7.[14] Examination of the variance explained confirms that the combined influence of the security environment and GDP on military expenditures is substantial. The $R^2$ for row 1 (without an AR correction or lagged dependent variable) is 0.78. The $R^2$ in each of the other equations is greater, but including an autoregressive correction and lagged dependent variables are not demanding tests.

To illustrate the economic significance of the results, consider the difference between the United States and New Zealand in the probability of a fatal dispute shown in Table 3. According to our estimates, this would lead to a difference in military spending as a percentage of GDP of a factor of 7.2 ( = exp [0.66 x 3] ). That is, the ratio of military expenditures to GDP for the U.S. should be more than seven times that of New Zealand. From Table 3, we see that it was actually five times as great for the period 1950-2000. This shows the large substantive impact the threat environment can have on military spending.[15]

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[14] The t-statistics for the long-run coefficient were calculated with local, non-linear estimators using numerical derivatives.

[15] To assess the danger that our results might be biased by a reciprocal effect of military spending on conflict, we added the logarithm of the higher and lower military expenditures for each dyad-year to the LRM. Consistent with preponderance theory, peace proved most likely when there is an imbalance of military spending. Increased spending has, therefore, an indeterminate effect, across all cases, on the threat environment. If it heightens the military imbalance in a dyad, the risk of war

To be sure that our analyses capture the experience of large, influential states as well as smaller countries, we estimated the specifications in Table 5 using only data for the 40 largest countries in terms of GDP. The same statistical issues arise for the large states as for the entire sample, and these were treated in the way we have just discussed. As seen in Table 6, the estimated semi-elasticities with respect to *p-hat* are somewhat smaller for the largest states than for all countries. The long-run semi-elasticities are about 2.4 (versus 2.8) for our preferred equation 3. We also ran an analysis limited to 14 global and regional powers (USA, Canada, Mexico, Brazil, Great Britain, France, Spain, Germany, Italy, USSR/Russia, China, Japan, India, and Indonesia), and again the results were very similar.

Although we do not focus primarily on the economic variables, real GDP does have a powerful impact on military spending, as expected. In virtually all the specifications, the long-run elasticity of military spending with respect to GDP is 1. For example, the long-run elasticity in Table 5 is estimated to be 1.0055 ($\pm$ 0.0087). The implication is that the ratio of military spending to GDP is essentially trendless once other variables are accounted for.

*More Complete Specifications*

Until now we have focused on different estimates of an equation that includes only our measure of the security environment, derived from the LRM, and GDP. We now extend the analysis in two steps to include a larger array of influences. First, we add measures of the military spending of friends and foes to control for the effects of arms races and alliance commitments. For this new specification, we again use our preferred estimate of the external threat (*p-hat* from column B, Table 2) and include all countries in the pooled panel analysis. The results are reported in Table 7. The estimated semi-elasticities of military spending with respect to the external threat are somewhat sensitive to the specification, the long-run coefficient being between 2.4 and 2.7, with the lower number holding for in our preferred specification (column 3). The reason is that measuring the military expenditures of friends and foes also captures important characteristics of the threat environment.

Interestingly, the expenditures of potential adversaries are more influential than those of friendly countries. There is evidence here of arms races with enemies and potential adversaries. If we look at column 3 of Table 7, the short-run elasticity of spending with respect to foes' spending is 0.10, while the long-run elasticity is 0.30. This indicates that a country increases its military spending by 1 percent in the short run and 3 percent in the long run if its potential adversaries increase their spending by 10

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goes down; but if it moves the two states toward equality in expenditures, the risk goes up. This suggests that conflict is not endogenous to military spending in a way that biases the results we report below.

percent. Even in the long run, this reaction coefficient does not suggest unstable arms races. Assuming that the coefficient is 0.3 for all countries, and that the probability of conflict is 50 percent per year, this implies that military spending approximately doubles because of the action and reaction through the foes variable.

Democracies spend less on the military, other things equal, than non-democratic states. We consider further the effects of national polities below. The results of analyses limited to the largest 40 countries, which are not shown, were very similar.

Next, we add two additional variables that reflect the presence of actual conflicts: an annual measure of a state's involvement in fatal disputes and the number of fatalities a country experienced in all conflicts in a year, normalized by its population. The results are shown in Table 8. The estimated semi-elasticities of military spending decline further, with the estimate for our preferred equation in the third column being about 1.7. The coefficient is again lower because the actual conflict variables are picking up more of the explanatory power of *p-hat*.

Tables 7 and 8 show that our prospective measure of the security environment is correlated with the retrospective measures we have added to the model of military expenditures. Nevertheless, the long-run effect attributable solely to the general external threat is substantial. It is remarkable that the predictions of the LRM are so influential with controls for arms races, the spending of allies, on-going disputes, and their intensity. Indeed, a comparison of the coefficients of *p-hat* and the actual rate of fatal MIDs indicates that the former exerts a greater influence on military spending. Clearly, states anticipate that they may become involved in militarized disputes and allocate resources to their armed forces accordingly. Those that exist in hostile security environments must arm, whether or not they actually end up fighting. Military spending is similar in this regard to insurance.

In sum, the long-run semi-elasticities of military spending with respect to the probability of being involved in a fatal dispute are in the range of 2.0 to 3.0. The precise value varies with the sample, the estimator used, and the other explanatory variables included in the specification.

*Democracy and military spending*

Next we assess the effect of democracy on military expenditures, holding other influences constant, including the threat environment. A simple regression of cross-national means, as in Table 4, provides a semi-elasticity of military spending with respect to our measure of democracy of -0.044 ( $\pm$ 0.011). Polity scores range from -10 for complete autocracy to 10 for a thoroughly democratic country. This suggests that autocracies will spend about 140 percent more than democracies on the military (= 100 x [exp(.88)-1]). The estimates of the impact of democracy on spending vary in different specifications reported in Tables 7 and 8, primarily because democracy is correlated with the other independent variables. A semi-elasticity of -0.03 is a reasonable mid-range estimate for the long-run effect, indicating that polar autocracies spend 80 percent more on the military than polar democracies. But *military* dictatorships (Gandhi and Przeworski 2006) spend no more than other dictatorships.

This estimated partial effect is in addition to the effect of democracy on the threat environment, which is also substantial. Using a simple regression of the means like that in Table 4, we estimate that the semi-elasticity of military spending with respect to the polity variable, with *p-hat* excluded, is -0.59. This suggests that the total impact of complete autocracy relative to complete democracy is to increase military spending by 220 percent. These results are less robust than our estimates of the impact of the threat environment, but they suggest nonetheless that democracy is an important determinant of military spending.

*Civil war and military spending*

How do civil wars affect military spending? Civil wars typically last much longer than international conflicts and are more likely to re-ignite after short periods of peace (Collier and Heffler 2007). Using data from Sambanis (2004), we estimated the impact of adding a variable that represents the probability of a civil war, similar in spirit to our *p-hat* variable. We examined the preferred equation (the third row in Table 5) with the variables shown in Tables 5, 7, and 8. The impact of civil wars on military spending is lower by a factor of around 10. For example, using the parsimonious specification in Table 5 and adding the probability of civil war, the short-run coefficient on *p-hat* is 0.805 ( $\pm$ 0.119) while the coefficient of civil war probability is 0.0799 ( $\pm$ 0.0285). In most specifications, if we account for autocorrelation (as in the fourth equation in Table 5), the estimated coefficients of the civil war variable are not significantly different from zero and are sometimes negative.

*Inclusion of Fixed Effects*

Analyses of panel data sometimes include country-fixed effects. We have treated our state-year observations as panel data without either country- or year-fixed effects for several reasons. First, there are strong theoretical grounds for believing that differences in the liberal and realist variables across countries significantly affect the probability of interstate conflict and, hence, national military expenditures. Looking at the average probabilities of conflict in Figure 2 and Table 3, or examining the scatter plot in Figure 3, suggests that cross-national influences vary substantially and are highly stable for individual countries.

A second important reason is evident if we consider the economic context of military spending. If we include country-fixed effects, a substantial part of the difference from trend within countries is likely to be determined by the business cycle and other short-term economic factors. To some extent, then, fixed effects may simply isolate Keynesian business-cycle correlations. This is a form of simultaneous equation bias that would be difficult to correct. In any event, we are not attempting to capture the influence of business cycles on military expenditures, or the reciprocal influence. The omission of country-fixed effects helps exclude such confounding influences.

Despite our reservations, we show estimates of our simplest model with fixed effects in Table 9. The coefficients for *p-hat* are smaller than before; but the estimates are quite significant statistically. The long-run semi-elasticities are about 1.0 for equations 3 and 4. We also estimated the basic equation, with just *p-hat* and GDP, for several individual countries, such as the United States, Canada, and New Zealand, but the standard errors of the coefficients of *p-hat* are too large for the results to be meaningful.

Comparing our pooled analyses with those that incorporate fixed effects leads to the following conclusion: The probability of becoming involved in a fatal dispute varies substantially across countries, and those differences have large effects on military spending across countries. However, if we examine changes in the threat environment for countries over time, the effect is much smaller, approximately one-third the size of the cross-sectional result reported in Table 4. This is undoubtedly due in part to temporal imprecision in the liberal-realist model itself, which we noted earlier; and in part to variability from country to country, or even over time for the same country, in the lag with which military spending adjusts to changes in the external environment. Thus, the substantial influence of the security environment on military expenditures, reported in Tables 3 – 8, is primarily the result of cross-national differences rather than variation in the external threat for individual countries through time.

*American Exceptionalism?*

As we explained, our preferred approach is to use pooled data to estimate general relationships. Yet, in future research it could be useful to ask whether particular countries, the United States for example, spend more or less than theoretically expected. This can be determined either by using dummy variables just for the countries of interest or by estimating fixed effects, which are in effect a set of dummy variables for each country. For this purpose, it seems best to use the full specification without the actual conflict variables. If we add only a dummy variable for the United States, the estimated coefficient is small and statistically insignificant. Relative to all other countries on average, the U.S. is not exceptional. However, with fixed effects for all countries, the U.S. effect is relatively large, indicating military spending around 80 percent above the theoretically derived predictions; and there are high peaks just before and after the end of the Cold War. This suggests that U.S. military spending is larger than can be explained by our economic, security, and geographical variables alone.

## Conclusions

We have used a widely accepted model of dyadic conflict, derived from liberal and realist theories of international relations, to investigate the relationship between a country's security environment and its military spending. No previous empirical study of national military expenditures has incorporated such a comprehensive, prospectively generated measure of the external threat. We focused on a nearly exhaustive sample of 165 countries for the post-World War II period, 1950-2000, but confirmed our findings with analyses of the 40 largest countries and 14 major and regional powers to ensure that our findings applied to these important nations.

Our research provides important external evidence for the validity of the liberal-realist model (LRM) and sheds new light on the determinants of military expenditures. Consistent with economists' normative approach, the degree of threat in a country's security environment is an important influence on its military expenditures. Indeed, the probability that a state will become involved in a fatal militarized interstate dispute, assessed ex ante by the LRM, is more influential than are any of several variables known only ex post: the actual incidence of states' involvement in serious interstate conflict, the intensity of these conflicts as measured by the number of combatants' fatalities, or the military expenditures of friends or potential foes. The chance of involvement in a fatal dispute varies greatly across countries, and those differences have large substantive effects on nations' allocations of resources to their armed forces.

The major result of this study is that the ex ante threat environment has an important effect on military spending. Our best estimate is that a one percentage point increase in the probability of a fatal dispute leads to an increase in military spending of between two and three percent of GDP, ceteris paribus. Several other findings are worth noting. Highly autocratic regimes spend much more on the military than do democracies or governments with mixed political characteristics. An increase in military spending by potential adversaries has only a small short-term effect but produces a long-term "arms race" effect of about 30 percent. The level of national output (measured by real GDP) has a powerful effect, as earlier studies have indicated. There appears to be an important inertial effect in military spending as well. Only 35 percent of the response in military spending to a shock in the security environment, to output, or to other variables takes place in the first year. We cannot determine whether the slow response occurs because of uncertainty regarding the permanence of change, mere bureaucratic inertia, or the economic consequences of the large sunk costs associated with the military's capital stock.

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| | Standard liberal-realist equation | |
|---|---|---|
| Estimation period | 1950-2000 | 1885-2000 |
| Dependent variable | fatinv_nc | fatinv_nc |
| Peace years | -0.0173 | -0.0148 |
| | *0.0046* | *0.0043* |
| Small democracy | -0.0822 | -0.0922 |
| | *0.0208* | *0.0193* |
| Large democracy | 0.0430 | 0.0449 |
| | *0.0131* | *0.0127* |
| Trade/GDP | -96.3400 | -88.0300 |
| | *35.0000* | *27.1400* |
| Contiguity | 1.4880 | 1.9740 |
| | *0.2990* | *0.2990* |
| Distance | -0.6180 | -0.5950 |
| | *0.1290* | *0.1090* |
| Ratio of GDPs | -0.2120 | -0.5390 |
| | *0.4350* | *0.4330* |
| Allies | -0.4800 | -0.3300 |
| | *0.2050* | *0.1960* |
| GDP relative to | 12.3000 | 9.6200 |
| world GDP | *1.3960* | *1.2610* |
| System size | -1.2260 | -0.7930 |
| | *0.2350* | *0.2040* |
| *Constant* | -1.2290 | -1.8040 |
| | *0.9070* | *0.8010* |
| Observations | 405,528 | 435,632 |
| Pseudo R-sq | 0.256 | 0.236 |
| Log likelihood | -2,673 | -3,072 |

Dependent variable (fatinv_nc) is a binary variable reflecting whether a dyad has a militarized interstate dispute(MID) in a year. The sample *excludes* "continuations," that is, second and further years of a continuing dispute.

**Table 1. Standard LRM equation for onset of militarized interstate conflict**
Each coefficient is shown with the standard error of the coefficient below in italics. The dependent variable *(fatinv_nc)* is a binary variable reflecting whether there is an onset of a fatal militarized interstate dispute (MID) in a year. The sample *excludes* "continuations," that is, second and subsequent years of an ongoing dispute.

| | Actual independent variables | | Historical instrumental variables | | Actual independent variables |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Dependent variable | fatinv_cont | fatinv_cont | fatinv_cont | fatinv_cont | fatinv_cont |
| Peace years | | | | | -0.0553 |
| | | | | | 0.0074 |
| Peace years IV | 0.0057 | | 0.0271 | | |
| | *0.0156* | | *0.0139* | | |
| Small democracy | -0.0860 | -0.0938 | -0.1170 | -0.1030 | -0.0889 |
| | *0.0264* | *0.0210* | *0.0338* | *0.0285* | *0.0193* |
| Large democracy | 0.0430 | 0.0419 | 0.0308 | 0.0401 | 0.0532 |
| | *0.0163* | *0.0134* | *0.0150* | *0.0154* | *0.0127* |
| Trade/GDP | -249.5000 | -192.9000 | -230.1000 | -185.2000 | -99.9900 |
| | *77.4900* | *63.3400* | *71.4900* | *65.0500* | *35.1200* |
| Contiguity | 1.6990 | 1.1980 | 1.4000 | 1.6950 | 0.9460 |
| | *0.4500* | *0.3030* | *0.4240* | *0.4170* | *0.3120* |
| Distance | -0.7850 | -0.6650 | -0.7660 | -0.7410 | -0.6200 |
| | *0.1780* | *0.1490* | *0.1660* | *0.1670* | *0.1320* |
| Ratio of GDPs | -0.5870 | -0.5030 | -0.4880 | -0.7250 | -0.3440 |
| | *0.5690* | *0.4830* | *0.5140* | *0.5490* | *0.4580* |
| Allies | -1.0060 | -0.9850 | -1.3630 | -0.8300 | -0.4030 |
| | *0.3780* | *0.2100* | *0.3370* | *0.2160* | *0.1950* |
| GDP relative to world GDP | 11.7400 | 11.4200 | 9.9500 | 11.9100 | 11.7200 |
| | *2.7370* | *1.9840* | *2.5250* | *2.0570* | *1.7130* |
| System size | -0.9690 | -1.3870 | -1.3140 | -0.9290 | -1.3850 |
| | *0.3790* | *0.2450* | *0.3460* | *0.3090* | *0.2460* |
| Constant | 0.1370 | -0.1050 | -0.3540 | -0.1960 | 0.3420 |
| | *1.3440* | *1.0510* | *1.2970* | *1.2260* | *0.9670* |
| Sample period | 1950-2000 | 1950-2000 | 1950-2000 | 1950-2000 | 1950-2000 |
| Observations | 371,080 | 406,067 | 371,062 | 405,923 | 406,067 |
| Pseudo R-sq | 0.267 | 0.252 | 0.259 | 0.255 | 0.297 |
| Pseudo log likelihood | -3710.5 | -4556.2 | -3667.4 | -3866.5 | -4285.8 |

Each coefficient is shown with standard error of the coefficient below in italics.
Dependent variable (fatinv_cont) is a binary variable reflecting whether
a dyad has a fatal militarized interstate dispute (MID) in a year. The sample
*includes* "continuations," that is, second and further years of a continuing dispute.

**Table 2. Alternative specifications of LRM with continuation sample**

Each coefficient is shown with its standard error below in italics.
Dependent variable *(fatinv_cont)* is a binary variable reflecting whether a dyad is involved in a fatal militarized interstate dispute (MID) in a year. The sample *includes* "continuations," that is, second and subsequent years of an ongoing dispute.

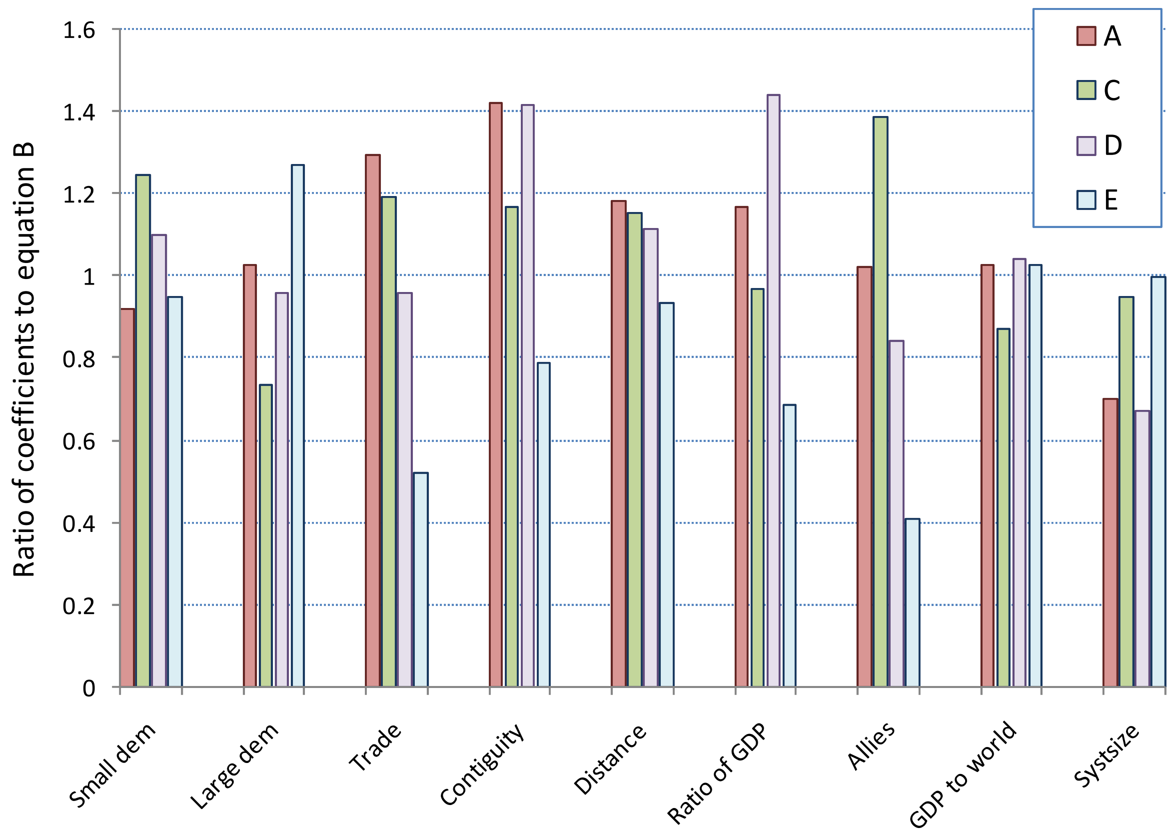


**Figure 1. Stability of coefficients in Table 2: Ratio of coefficient in specification A, C, D, or E to specification B**

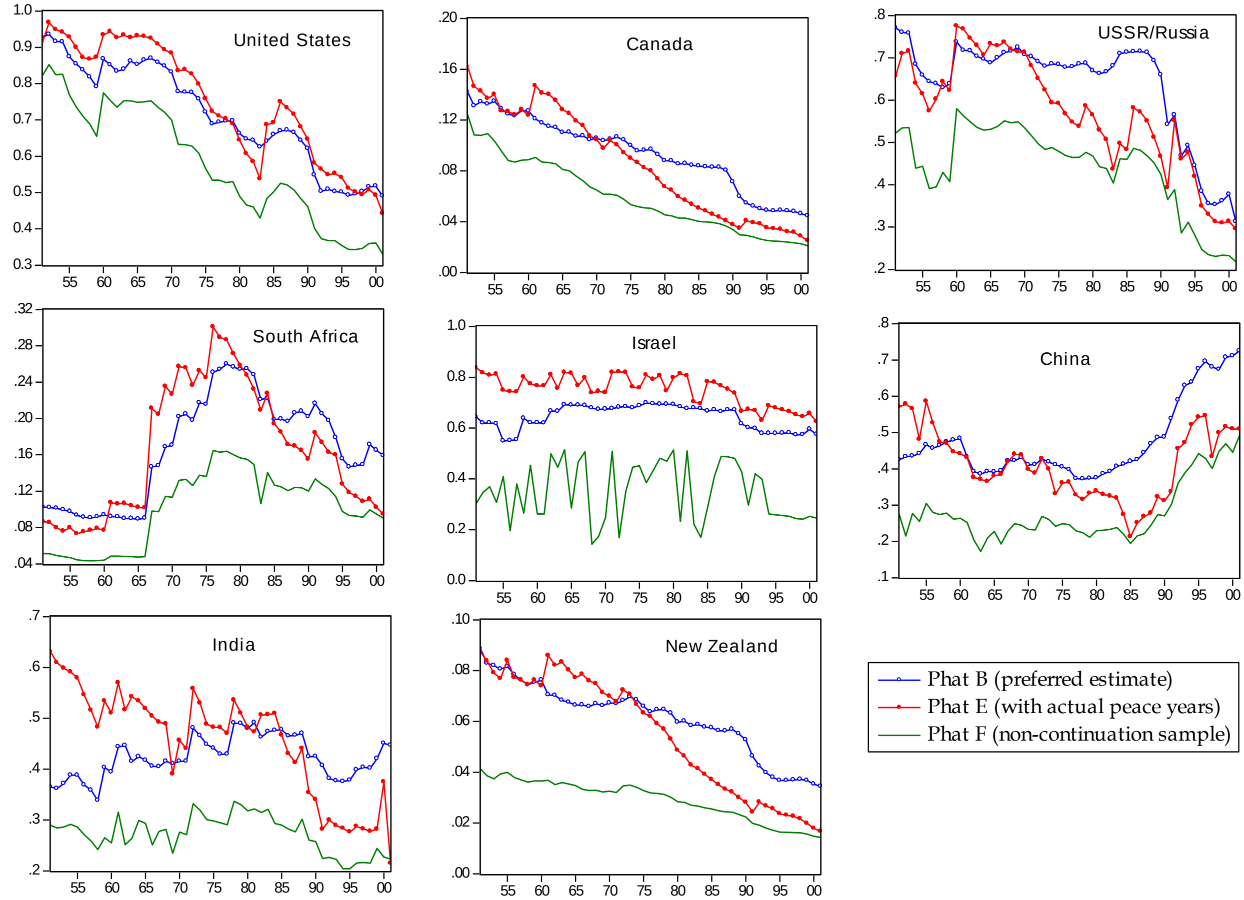


**Figure 2. Calculated probability of conflict for eight representative countries, 1950 – 2000**
These graphs show the estimated probability of conflict (fatal MID) for eight countries through time. Note the differences in the left-hand scale. Three estimates are shown for each country. The preferred estimate excludes peace years and uses the actual independent variables. The variant with actual peace years has excessive volatility (see Israel); the series generated using the non-continuation sample with actual peace years is even noisier.

| Country | Probability of fatal MID (% per year) | Military spending/ GDP (%) |
|---|---|---|
| New Zealand | 6.1 | 1.2 |
| Australia | 7.0 | 2.0 |
| Chile | 8.5 | 1.6 |
| Canada | 9.4 | 2.3 |
| | | |
| USSR/Russia | 63.6 | 10.0 |
| Democratic Republic Congo | 63.9 | 0.4 |
| Israel | 64.2 | 6.4 |
| United States | 71.7 | 6.0 |

**Table 3. Estimated Probability of Conflict and Military Spending Ratio, 1950-2000, for Countries with Largest and Smallest Conflict Probabilities**

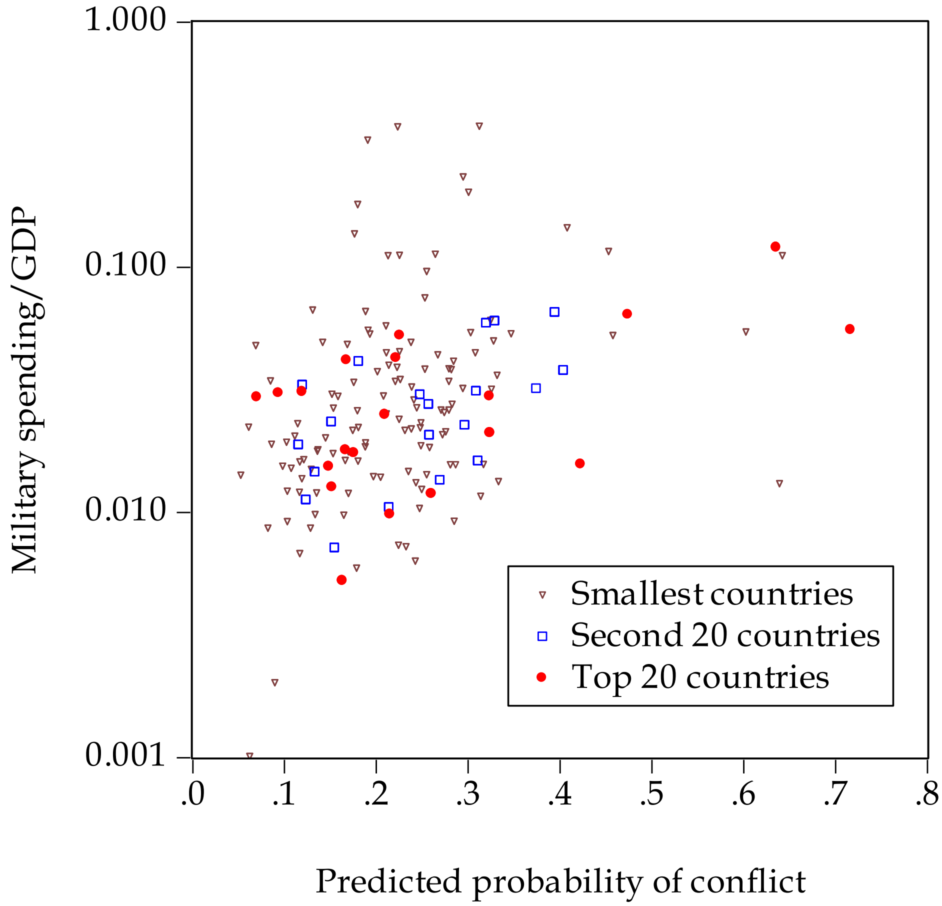


**Figure 3. Scatter plot of mean probability of conflict and military spending fraction for each state, 1950-2000**

Dependent variable: mean [ln (military spending)]

| Independent variables | Coefficient | Std. Error | t-Statistic |
|---|---|---|---|
| Mean [probability of MID] | 3.20 | 0.63 | 5.10 |
| Mean [ln (real GDP)] | 0.98 | 0.04 | 24.02 |
| | | | |
| R-squared | 0.812 | | |
| Adjusted R-squared | 0.810 | | |
| S.E. of regression | 0.879 | | |
| Sum squared resid | 125.2 | | |
| Log likelihood | -211.3 | | |
| Observations | 165 | | |

**Table 4. Estimate of effect of probability of conflict on military spending, country means**

This regression is the simplest specification for estimating the relationships among the three variables, 1950-2000. The dependent variable is the logarithm of real military spending. The independent variables are the probability of a fatal militarized interstate conflict and the logarithm of real GDP. The regression is a pure cross-section of national means.

| Pooled | | | | | | Semi-elasticity of Milex with respect to p-hat | |
|---|---|---|---|---|---|---|---|
| | phat_b | ln(rgdp) | AR | Milexp(-1) | Milex Unit root | Short run | Long run |
| Pooled, No LDV | 0.622 | 0.655 | 0.958 | | | 0.622 | 0.622 |
| | *0.202* | *0.040* | *0.003* | | | *0.202* | *0.202* |
| Pooled, LDV | 0.159 | 0.040 | -0.092 | 0.956 | 0.044 | 0.159 | 3.629 |
| | *0.028* | *0.004* | *0.013* | *0.004* | *0.004* | *0.028* | *0.596* |
| IV on LDV, no AR | 0.979 | 0.352 | | 0.650 | 0.350 | 0.979 | 2.789 |
| | *0.145* | *0.053* | | *0.052* | *0.052* | *0.145* | *0.118* |
| IV on LDV with AR | 0.739 | 0.099 | 0.989 | 0.796 | 0.204 | 0.739 | 2.782 |
| | *0.278* | *0.086* | *0.030* | *0.170* | *0.170* | *0.278* | *0.107* |

**Table 5. Analyses of military expenditures, 1950-2000, all countries**

These show the results of equation (2) in the text using only *p-hat*, real GDP, and (in three cases) lagged military spending as independent variables. The different tests are described in the text. Row 3 is the preferred specification.

The dependent variable is the logarithm of real military spending *(Milexp)*. The independent variables are the probability of a fatal militarized interstate conflict *(phat_b)*, and the logarithm of real GDP *ln(rgdp)*. The column *AR* indicates that we have estimated a first-order autoregressive process. *Milexp(-1)* is a lagged dependent variable. *"Milex unit root"* tests for the difference of the military spending coefficient from 1. The last columns show the semi-elasticities, which are defined as the percent change in military spending per unit change in the probability.

| **Pooled** | | | | | Milex | Semi-elasticity of Milex with respect to p-hat | |
|---|---|---|---|---|---|---|---|
| | phat_b | ln(rgdp) | AR | Milexp(-1) | Unit root | Short run | Long run |
| Pooled, No LDV | 0.502 | 0.727 | 0.962 | | | 0.502 | 0.502 |
| | *0.262* | *0.074* | *0.006* | | | *0.262* | *0.262* |
| Pooled, LDV | 0.202 | 0.040 | 0.027 | 0.942 | 0.058 | 0.202 | 3.477 |
| | *0.036* | *0.007* | *0.024* | *0.007* | *0.007* | *0.036* | *0.590* |
| IV on LDV, no AR | 0.680 | 0.242 | | 0.716 | 0.716 | 0.680 | 2.362 |
| | *0.126* | *0.044* | | *0.045* | *0.045* | *0.126* | *0.148* |
| IV on LDV with AR | 0.965 | 0.234 | (0.256) | 0.707 | 0.293 | 0.965 | 2.355 |
| | *0.039* | *0.039* | *0.528* | *0.046* | *0.046* | *0.039* | *0.141* |

**Table 6. Analyses of military expenditures, 1950-2000, largest 40 countries**
These show the results of equation (2) in the text using only *p-hat*, real GDP, and (in three cases) lagged military spending as independent variables. For these estimates, the sample is limited to the largest 40 countries ranked by GDP. The different tests are described in the text. Row 3 is the preferred specification.
For a definition of the variables, see Table 5.

| Independent variable | Pooled, No LDV | Pooled, LDV | IV on LDV, no AR | IV on LDV with AR |
|---|---|---|---|---|
| *phat_b* | 0.6134 | 0.1205 | 0.6519 | 0.7120 |
| | *0.2002* | *0.0289* | *0.0913* | *0.2714* |
| *ln(rgdp)* | 0.7091 | 0.0519 | 0.3338 | 0.1378 |
| | *0.0372* | *0.0044* | *0.0435* | *0.0820* |
| *Milexp(-1)* | | 0.9489 | 0.6842 | 0.7399 |
| | | *0.0037* | *0.0407* | *0.1613* |
| *ln(Foes)* | *0.1174* | *0.0150* | *0.0952* | *0.0263* |
| | *0.0373* | *0.0103* | *0.0194* | *0.0500* |
| *ln(Friends)* | 0.0095 | -0.0035 | -0.0007 | -0.0001 |
| | *0.0083* | *0.0032* | *0.0047* | *0.0106* |
| *Democ* | -0.0056 | -0.0025 | -0.0108 | -0.0015 |
| | *0.0022* | *0.0005* | *0.0015* | *0.0029* |
| Long-run semi-elasticity milex w.r.t. phat | 0.613 | 2.36 | 2.36 | 2.74 |
| Standard error of long run | *0.303* | *0.55* | *0.55* | *0.57* |
| $R^2$ | 0.980 | 0.983 | 0.969 | 0.968 |
| Observations | 5,917 | 5,707 | 5,707 | 5,707 |

**Table 7. Analyses of the logarithm of military expenditures, 1950-2000, all countries, with additional control variables**

For a definition of key variables, see Table 5. Additional variables are: *Friends* is the logarithm of the weighted military spending of those who are allied with the country; *Foes* is the logarithm of the weighted military spending of those who are not allied with the country; *Democ* is the polity score.

| Independent variable | Pooled, No LDV | Pooled, LDV | IV on LDV, no AR | IV on LDV with AR |
|---|---|---|---|---|
| *phat_b* | 0.6236 | 0.1001 | 0.418 | 0.725 |
| | *0.2000* | *0.0297* | *0.064* | *0.272* |
| *ln(rgdp)* | 0.7134 | 0.0544 | 0.251 | 0.141 |
| | *0.0370* | *0.0045* | *0.032* | *0.081* |
| *Milexp(-1)* | | 0.9461 | 0.761 | 0.742 |
| | | *0.0037* | *0.030* | *0.159* |
| *ln(Foes)* | 0.1166 | 0.0142 | 0.066 | 0.023 |
| | *0.0373* | *0.0103* | *0.016* | *0.050* |
| *ln(Friends)* | 0.0094 | -0.0030 | 0.0000 | -0.0004 |
| | *0.0083* | 0.0032 | *0.0041* | *0.0106* |
| *democ* | -0.0057 | -0.0026 | -0.0085 | -0.0015 |
| | 0.0022 | 0.0005 | *0.0011* | *0.0029* |
| *p-actual* | 0.0169 | 0.0397 | 0.013 | 0.027 |
| | *0.0173* | *0.0148* | *0.122* | *0.022* |
| *Number fatalities* | 31.03 | 28.7 | 93.0 | 51.0 |
| | *15.14* | *10.8* | *17.2* | *21.7* |
| Long-run semi-elasticity milex w.r.t. phat | 0.624 | 1.857 | 1.749 | 3.562 |
| Standard error of long run | *0.200* | *0.539* | 0.171 | *1.578* |
| $R^2$ | 0.980 | 0.983 | 0.976 | 0.968 |
| Observations | 5,917 | 5,707 | 5,770 | 5,707 |

**Table 8. Analyses of military expenditures, 1950-2000, all countries, with full specification**

For a definition of key variables, see Tables 5 and 7. *p-actual* is the ex post frequency of fatal MIDs aggregated as explained in the text; *Number fatalities* is the number of combatant fatalities divided by a country's population.

| Fixed effects | phat_b | ln(rgdp) | AR | Milexp(-1) | Milex Unit root | Semi-elasticity of Milex with respect to p-hat Short run | Long run |
|---|---|---|---|---|---|---|---|
| No LDV | 0.238 | 0.565 | 0.831 | | | 0.238 | 0.238 |
| | *0.198* | *0.036* | *0.006* | | | *0.565* | *0.565* |
| LDV | 0.245 | 0.106 | -0.086 | 0.865 | 0.135 | 0.245 | 1.820 |
| | *0.071* | *0.009* | *0.014* | *0.007* | *0.007* | *0.106* | *0.532* |
| IV on LDV, no AR | 0.326 | 0.259 | | 0.696 | 0.304 | 0.326 | 1.058 |
| | *0.083* | *0.032* | | *0.035* | *0.035* | *0.259* | *0.275* |
| IV on LDV with AR | 0.319 | 0.259 | 0.010 | 0.695 | 0.305 | 0.319 | 0.910 |
| | *0.083* | *0.037* | *0.464* | *0.039* | *0.039* | *0.259* | *0.211* |

**Table 9. Analyses of military expenditures, 1950-2000, all countries, with country-fixed effects**

For a definition of the variables, see Table 5.