The Effects of the Security Environment on Military Expenditures: Pooled Analyses of 159 Countries, 1950-2000[1]

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Abstract

The military expenditures of countries differ greatly across both space and time. Here we examine the determinants of military spending, with particular reference to the importance of the 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 estimates of the likelihood of dyadic conflict, calculating ex ante the annual probability that a country will be involved in a fatal dispute. This is our measure of the hostility of the security environment. We then estimate the level of military spending by country and year as a function of the security environment, arms races, states' involvement in actual military conflict, economic output, and various political variables. Using a panel of 159 countries over the period 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 dispute leads to a 3 percentage point increase in military spending.

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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 central question: who arms heavily, and why? Countries vary enormously in the proportion of their resources they devote to military purposes, with Costa Rica at one end and large and middle range powers facing many perceived external threats at the other. Great differences in military spending are evident between states that superficially appear similar in resources or geopolitical position.

In this examination we undertake two tasks, using an almost complete sample of countries over the second half of the twentieth century. First, we measure the level of threat of conflict in the security environments of different countries using the predictions of the dyadic liberal-realist model (LRM) of interstate conflict. 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 aggregate the predictions of the LRM to the state level and use these annual estimates of countries' security environments to explain their military expenditures. Economic models of the demand for military spending typically treat it as an optimization problem, with a demand function to maximize external security from a threat (typically rivals' military spending), subject to a budget constraint, expenditures of allies, and spillover of private goods such as internal security. These influences vary greatly both across countries and over time. Some exhibit a high degree of inertia, from processes such as arms races or the experience of violent conflict, and from internal influences such as organizational inertia or a "military-industrial complex." The major innovation in our study is to develop and use measures of the external threat in the security environment; these are measured ex ante as the predicted probability of a militarized dispute using the LRM, and ex post by the actual frequency of disputes as well as the fatality rate in actual conflicts.

That the external threat should influence national military spending is hardly surprising. However, the major result of the present study is that the ex ante threat or probability of a militarized interstate dispute (MID) is a powerful determinant of military spending. Based on the LRM and estimates of the determinants of dyadic disputes, we find that a one percentage point higher aggregate probability of MIDs for a country leads to a 3 percent increase in military spending. We also find that a country's size, measured by its gross domestic product (GDP) is a powerful determinant of its military spending. Additionally, we find that there are important inertial elements in spending, with spending responding with a sizable lag to changes in output or the level of the threat. It is interesting to note that the ex ante probability of conflict is a more robust and sizable determinant of military spending than are the ex post measures.

In addition to the findings about the determinants of military spending, our research provides a valuable "external" test (Lakotos 1978) of the validity of the widely accepted LRM by demonstrating its ability to generate important predictions about additional phenomena, national military expenditures. To our knowledge, this is the first time that any international relations study has used such a measure of external threat as an explanatory variable.

The Liberal-Realist Model (LRM) of Dyadic Conflict

We begin with a brief discussion of the determinants of interstate conflict incorporated in the liberal-realist model. We then consider some of the statistical issues that arise in using this equation. In the following 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.

Recent research on the causes of war has increasingly relied upon pooled dyadic time series. Under this approach, the sampling frame is the relations between two countries in a given year (a "dyad-year"). The important variable is the occurrence of a violent dispute between the two countries, which is taken to be a function of political and economic characteristics of the two countries individually, along with certain dyadic features such as trade, alliances, and geography. Such an analysis would include, 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 individual and dyadic characteristics and even variables measures at the level of the international system. 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 also include 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 incorporate 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 leading 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 value 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 beyond their boundaries; an indicator of a defense pact, non-aggression treaty, entente, or other security agreement; and measures of geographic proximity. We also consider each dyad's historical experience of violence, measured by the number of years of peace since its last fatal militarized interstate dispute (MID). As we will show, however, this variable introduces serious statistical problems.

We write the standard LRM model as follows:

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

Here $p_{i,j}^{fatal}(t)$ is the dyadic-year probability (occurrence) of a fatal militarized dispute, one involving at least one combatant's death, between states *i* and *j*. This variable is coded as equal to one when a dispute occurs and zero when there is no dispute. The other variables in equation (1) are ones that have been developed in the literature on predicting the onset of disputes. We capture the effect of states' political regimes on the likelihood of conflict using the lower and higher democracy score in a dyad (Oneal and Russett 1997). Economic interdependence is represented by the lower bilateral trade-to-GDP ratio; this 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 measure is taken to represent in a simple way the probability that the larger state will win a military contest. [2] We measure the ability of the more powerful state to project its military capabilities, indicated by the logarithm of the larger state's 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

[2] Trade and GDP are from Gleditsch 2002, current version at his website: http://privatewww.essex.ac.uk/~ksg/exptradegdp.html

indicator of contiguity and the logarithm of the capital-to-capital distance separating the 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 have omitted that in this study 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 (forthcoming) provide the details regarding the definitions of these variables and the sources of our data.

Estimates of the onset of militarized interstate disputes.

Table 1 reports in the first two columns 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 is analyzed through time using logistic regression analysis. There are 435,632 and 405,528 observations (dyad-years), respectively. [3] The estimates were made using a panel estimator in STATA 10.1. Fixed country or time effects are not included, and the robust standard errors are adjusted for clustering by dyad. (These estimates include only onsets, which are the first year of a dispute. The estimates in Table 1 exclude subsequent years of a dispute as recommended by Beck, Katz, and Tucker (1998)).

The results of our analyses for 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 increases disputes. (4) Major powers are prone to fight, presumably because their interests are global 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 an explicit security agreement. (6) Conflict is much more likely for states that are geographically proximate. As a result of the strength of these influences, the predicted values derived from the LRM vary substantially across dyads as does the actual rate of their involvement in interstate conflict.

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[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.

Note that the first column of results in Table 1 will correspond to column E of Table 2. The only difference between these two estimates is that Table 1 uses only onsets (the non-continuation sample), while Table 2 column E uses the continuation sample.

Many unanswered questions remain in research on the causes of war 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 go to war (Glick and Taylor forthcoming). 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 assess the probability that an earthquake will strike a particular region with considerable accuracy, but they cannot predict its timing well. Similarly, the likelihood of conflict for some states is far lower than for others, but we cannot predict well when a conflict for even the conflict-prone countries will break out.

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 for our purposes because it does not accurately capture the severity of the external military threat. If states anticipate the possibility of becoming involved in a protracted major war, they would be expected to spend more on the military than if only brief conflicts are anticipated. We therefore use a "continuation sample," in which all dyad-years of all disputes are included, to assess the threat environment for inclusion in our analyses of military expenditures.

Including all years of disputes in the continuation sample leads to biased estimates of the regression coefficients, however, if we include "peace-years" in equation (1). The difficulty arises because it introduces a bias in the continuation sample. A numerical example will explain this problem. Suppose that there is no actual relationship between peace-years and the onset of disputes. So a regression of the probability of onsets of disputes on peace-years will have an expected coefficient of zero. However, if we consider the continuation sample, roughly half the years coded one would represent the second, third, or further years of a dispute. After the first year of the dispute, the peace-years variable will be set to zero. For the continuation years, therefore, there will be an inverse relationship between peace-years and the probability of conflict. This inverse relationship is completely uninformative, however. It is simply an artifact of the construction of the peace-years variable.

An actual example of this syndrome is a dyadic regression using only the United States and North Korea over the period 1950-2000. If we use only the 34 years of onsets, a simple logistic regression of the probability of a MID has a coefficient on peace-years of -0.054 ($\pm$ 0.14). However, this dyadic relationship has 9 years that were dispute continuations. If we include all years, the coefficient falls to -0.498 ($\pm$ 0.21). The downward bias is due to the fact that continuations of disputes are always associated with a zero value of peace-years.

This discussion indicates that, if we use the continuation sample (i.e., all dyad-years), then 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 even the structure of government may change over the course of a major war. 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. They will turn out to be unimportant, so we will discuss them only cursorily.

Table 2 reports five sets of estimated coefficients of equation (1) with a continuation sample for the years 1950-2000. Column E, for reference purposes, gives the results of using the actual years of peace in the equation with continuations and is therefore the same specification as the first numerical column of Table 1. Columns A through D show four different specifications of the continuations equation 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. Columns C and D show the same equations but substituting the historical IVs for the independent variables.

Begin by comparing column E in Table 2 with the IV versions in columns A and C as well as the estimated coefficient on PY in Table 1. The coefficient in E is much more negative than the other estimates, indicating that the negative bias discussed earlier is indeed present in 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 equation A and marginally significant in equation C. This suggests that the reason why peace-years is significant in column E is because of its correlation with further years of conflict rather than because it contains information about prior values of the other independent variables.

Figure 1 shows the stability of the coefficient estimates by graphing the ratio of each coefficient to its estimate in column B, our preferred specification. The graphs confirm that major differences appear between estimator 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.[4]

In our analysis of military spending, we focus our discussion primarily on the specification in column B of Table 2 as 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 in columns A and C, so that suggests that those specifications are not superior. Third, there appear to be no statistically significant differences between the historical IV in equation D and the analysis with the actual variables in equation B, but the coefficients in equation B 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 the estimates of the security environment that will be included in our analysis 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 estimate the threats in the security environment for each country. 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 dyadic-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 probability per year that a

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[4] Some of the differences are due to different samples since using the IV variables reduces the sample size.

state will be involved in a fatal dispute with at least one other country, using the standard calculation of a joint probability from the individual components:

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

In this calculation, $\hat{p}_i^{fatal}(t)$ is the calculated state-year probability of a fatal MID for state *i* in year *t*, and $\hat{p}_{i,j}^{fatal}(t)$ is the estimated dyadic-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 representative estimates of the time series ex ante annual probabilities of a dispute for eight important countries in Figure 2. The left-hand axis shows the predicted probability of a fatal dispute with at least one other country. "*Phat B*" is our preferred specification B in Table 2. "*Phat E*" is the specification E with actual peace years in the continuation sample. "*Phat F*" uses the estimates from the non-continuation sample. The appendix provides the detailed list of countries and their *p-hat* estimates.

We interpret the graphs as showing the severity of the external threat of conflict faced by each country over time. These differences in our *Phat B* variable are purely the result of the predictors derived from liberal and realist theories; the estimates 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, USSR/Russia, China, and Israel and low-conflict countries such as Canada, South Africa or New Zealand. Note as well that for all countries except China, there has been a significant decline in the probability of a dispute with the end of the cold war.

The problem with using the actual peace-years in estimating *p-hat* is evident in Figure 2. The time series produced with peace-years in the specification *(p-hat E)* move more erratically and are strongly influenced by the 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 top 40 countries.

<u>Explaining National Military Expenditures</u>

We now turn to the principal focus of this paper: 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 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 data on the military spending of foes.

We begin with some analytical background. We can distinguish normative from positive theories of military expenditures. The normative approach views military spending as a national public good (with transnational spillovers) responding to "objective" military threats and ongoing conflict. According to normative theory, nations provide their citizens with security from external threats by spending money on the armed forces. These expenditures are, of course, limited by the size of the national economy. A nation's security environment is determined primarily by the likelihood of military conflict and the cost of any ongoing militarized disputes. In the analyses below, we are particularly interested in the security environment as estimated with the liberal-realist model: the annual, prospectively estimated probability that a state will become involved in at least one fatal MID.

The positive approach includes various elements such as the power of the "military-industrial complex," bureaucratic inertia, arms races, and domestic politics (Russett 1970) as well as the normative elements. The present analysis combines the two approaches, but the major research question is, how are military expenditures influenced by the objective character of nations' circumstances? Our analyses might be viewed as testing the relative importance of the normative and positive approaches. That interpretation fits with the characterization, common among economists, of military expenditures as an optimization problem, with a demand function to maximize external security from a threat, subject to a budget constraint, the expenditures of allies, and the spillover from private goods such as internal security.[5] These influences vary sharply both across countries and over time.

Table 3 shows the most and least conflict-prone countries in our sample, along with the average of their military expenditure-to-GDP ratios. The difference in the security environments between the two groups is striking, and it seems 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 in danger 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

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

In the analyses that follow, we examine 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 demobilization of victors and vanquished, and the shortage of data for the immediate postwar years. We stop in 2000 because some data are available only through that year. We report results for two samples: 159 countries, for which we have 6607 observations; and the 40 countries with the largest GDPs in 1980, for which there are 1906 observations.

Though we focus on the impact of the threat environment on military spending, we also consider several other potentially important influences. The most important of these, of course, is 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 variables captures the effect of arms races among countries and of 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. Military spending of adversaries has been the most common way of measuring threats in arms race theorizing, long modeled as an action-reaction cycle.[6] Conversely, alliances and informal international agreements often carry a commitment for support in particular circumstances, which can manifest itself as greater spending by states on their armed forces.[7]

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

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

[7] The canonical reference is Olson and Zeckhauser (1966) on the collective action implications for proportionately high spending by the biggest state(s) in an alliance and proportionately lower spending by smaller "free-riding" states. The predicted net effect for the alliance as a whole is lower (suboptimal) spending. More recently, see Murdoch (1995), Sandler and Hartley 1995, Chapter 2, Murdoch and Sandler (1995), Oneal and Whatley (1996) and the articles reproduced as chapters 22-26 in Hartley and Sandler, eds. (2001). The "friends" variable does not completely capture issues raised by the presence of alliances. That question is beyond the scope of the present study.

states alliance portfolios. Following Bueno de Mesquita (1981), we assume in constructing these indices that countries that have the same allies (and the same non-allies) have similar or complementary foreign policies and security interests.

Using Signorino's *S*, we ranked all states according to the similarity of their alliance portfolio in each year. Those states above the median in each year 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 a measure of 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 influence of other states' contemporaneous military expenditures. In the regression analysis, we take the logarithm of spending of foes and friends to put them on the same scale as military spending.

In addition to capturing the influence of alliance commitments for coordinated expenditures with friends and the consequences of arms races with potential foes, the military spending of friends and foes is also a way of controlling 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 the dispute does not draw it immediately into the conflict.

Actual conflict. Some measure of violent international conflict is a common indicator of external threat in models to explain military spending. We address the influence of actual, ongoing conflict on military expenditures using two variables. The first ex post measure is the incidence rate of fatal disputes for each country in each year. We started by calculating the fraction of a state's dyadic relations that were marked by a fatal militarized dispute, this being the total number of conflicts, $\sum_{j=1}^{n} p_{i,j}^{fatal}(t)$, divided by *n,* the total number of states. Here, as above, $\sum_{j=1}^{n} p_{i,j}^{fatal}(t)$ is the ex post frequency of disputes (equal to 0 if no dispute occurred and equal to 1 if a dispute occurred). We then construct the ex post frequency of disputes by the following:

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

In this formula, $p\text{–}act_i(t)$ is the fraction of the dyadic relationships of state *i* that *actually* had a dispute in year t, and *n* is the number of dyadic relationship for county *i* in year t. This definition has the same units as equation (2) above and is thus the ex post concept that is parallel to our *p-hat* variable. The advantage of using the *p-actual* variable is that the coefficient estimated in the analyses below is directly comparable to that of *p-hat,* our ex ante measure of the external threat.[8] Naturally, we expect that states that do experience a higher incidence of fatal militarized disputes will spend more on their armed forces.[9]

In addition to the number of disputes in which a country is involved, national military expenditures should reflect the intensity of those conflicts. Therefore, the second ex post gauge of the military spending required is the number fatalities a country suffered in conflicts with all other states in a year, normalized by the population of the country.[10] 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.

It is important to emphasize that *p-hat* (the state-year estimate of threat we derive from the LRM) is an ex ante or a prospective measure of the dangers in a country's security environment. This measure will affect 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 two 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 the cost of actually defending territory. For states that go beyond the status quo and use their military capabilities to promote their interests, this can be done either by means of coercive diplomacy or by actual force of arms (Jackson and Morelli 2008). States should prefer coercive diplomacy, just as they prefer deterrence, because the cost—in human

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[8] 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 of all violent interstate conflicts. We also ran tests substituting 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 table.

[9] Since our measures of the external threat environment depend largely on the behavior of other states, emergent threats from non-state actors (e.g., terrorists) have little impact in this model.

[10] Fordham and Walker (2005) use battle deaths in wars, but not varying by time period, and do not include MIDs. Our information is from a newly compiled dyad-year dataset of fatalities (Pleschinger and Russett, 2008).

life especially—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.

Thus, we expect national military expenditures to be a function of policy makers' ex ante estimates of the armed forces necessary for security given the environment in which they expect to operate. They will normally seek to deter some 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; and 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, and to fear that a strong military establishment may suppress civil liberties. A contemporary version 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 costs on the general population. Hence autocracies should spend proportionately more on the military. [11]

Bureaucratic or organizational inertia. The final category reflects the fact that military spending has great inertia and may react slowly to changes in the security environment, especially to the disappearance of great threats. For example, after the end of the Cold War, military spending in most countries that were involved declined relatively slowly. There are many reasons for this inertia, including the putative lobbying power of vested interests sometimes called the "military-industrial complex" in Western democracies, uncertainty regarding the permanence of change, and the difficulties of dismantling a system with a large overhead.

In the estimates that follow, 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

[11] See Fordham and Walker (2005); Goldsmith (2003); and for a different reason Garfinkle (1994). Democracies may be able to spend more in wartime (Bueno de Mesquita et al. 2004).

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 with this specification is bias due to autocorrelated errors. We take steps to correct for this below.

Putting all these together, we get the following full specification:

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

All the variables have been defined above, but we note again that the error term may have autoregressive properties that need attention.

Empirical Estimates of the Determinants of Military Expenditures: Results

We can start with a visual examination of Figure 3 in deciding whether nations' security environments influence their military spending. The bivariate scatter plot there shows the mean probability of conflict 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] The top 40 countries are shown as darker circles. 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 there are clearly other forces at work.

Additionally, we provide in the appendix a complete list of states along with their ratio of military spending to GDP over the sample period as well as our estimate of the probability of conflict. This table shows how different are the security environments of different countries.

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[12] Cross-national estimates of military expenditure are difficult to evaluate and subject to error (Lebovic 1998, Smith 1995, Dunn and Smith 2007). Comparability is greatest among democracies and developed economies. Data for China and USSR/Russia are notably controversial. Estimates for some countries may exhibit analysts' inertia (i.e., extrapolating from initial analytical assumptions). After close examination of a wide variety of 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 data from the Stockholm International Peace Research Institute (http://www.sipri.org/contents/milap/milex/mex_data_index.html) more plausible for subsequent years. The two series are nevertheless highly correlated, so we extended the SIPRI data backwards by regressing on COW's estimates. We then converted the data to PPP-based estimates. COW showed a very large drop in Chinese military spending in 1985 continuing into 1988. Because that conflicts with all other reports, we raised our estimate consistent with SIPRI's. Similar concern about a drop in SIPRI data for Russia/USSR from 1988 to 1991 was not supported in other estimates, so we made no change.

Table 4 begins with the simplest specification of equation (2) using the means of the variables for each country. For this, we estimate the effect of the security environment *(p-hat)* on the logarithm of military expenditures, controlling only for a country's economic size, using cross-national averages for each variable. 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 159 countries, 1950-2000 of the simple specification that includes only *p-hat* and economic size. 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 as instruments in all runs. We found that there is 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 in rows 3 and 4 respectively.[13]

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 the coefficient substantially. The estimated coefficient of the LDV is important because it is λ in the adjustment equation described above; and $1 - \lambda$ is used to calculate the long-run impacts of our independent variables. Second, the coefficient on *p-hat* (and on 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

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[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.

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 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. The long-run semi-elasticity, calculated as the short-run semi-elasticity divided by (1 – λ), is about 3, as seen in the last column of the table. The t-statistics on the *p-hat*s are high by conventional standards. Taking equation 3 as an example, the t-statistic on the short-run elasticity is 6.7.[14] An 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 any AR 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 illustrates how the threat environment can have a major impact on military spending.[15]

We want to be sure that our analyses capture the experience of large, influential states as well as smaller countries. We therefore estimated the basic equation with the specifications in Table 5 using only data for the forty largest countries in terms of GDP.

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[14] The t-statistics for the long-run coefficient were calculated using non-linear estimators. They are local 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 goes down; if it moves the two states toward equality in expenditures, the risk goes up. This helps reduce the danger that conflict is endogenous to military spending in a way that biases our results.

The same statistical issues arise for the large states as for the entire sample, and these were treated in the same 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 that was limited to fourteen global and regional powers, and again the results were very similar.[16]

Although this study does not focus primarily on the economic variables, we note that real GDP has a powerful impact on military spending, as is well known. 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 of this result 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 the military expenditures of friends and foes also capture 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 0.3. This indicates that a country increases its military spending by 1 percent in the short run and around 3 percent in the long run if its potential adversaries increase their spending by 10 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

[16] The fourteen are the United States, Canada, Mexico, Brazil, Great Britain, France, Spain, Germany, Italy, the USSR/Russia, China, Japan, India, and Indonesia.

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 forty countries, which are not shown, were very similar.

As a final test, we add two additional variables that reflect the presence of actual conflicts: a 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 lower because the actual conflict variables are picking up some of the ex ante threat variable's explanatory power.

Tables 7 and 8 show that our prospective measure of the security environment is correlated with the retrospective measures we have added. Nevertheless, the long-run effect attributable solely to the general external threat is substantial. It is remarkable that the predictions of the LRM are still 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. 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 to 3. The precise value depends upon the sample of countries, the estimator used, and the other independent 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 analysis of cross-national means, such as that in Table 4, provides a semi-elasticity of military spending with respect to our measure of democracy variable of -0.044 (± 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 (the number is derived as 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, other things held constant. .[17]

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

One question is how the presence of civil wars affects military spending. Civil wars typically last much longer than international wars and are much 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 (as in the third equation 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, the short-run coefficient on *p-hat* is 0.77 ($\pm$ 0.025) while the coefficient of civil war probability is 0.075 ($\pm$ 0.025). In most specifications, if we add an autocorrelated error (as in the fourth equation in Table 5), the coefficients are usually insignificantly different from zero.

Inclusion of Fixed Effects

Analysis of panel data often relies primarily on estimates that include country fixed effects rather than pooled data. This analysis has treated our state-year observations as panel data without time or country-fixed effects for the following reasons. First, there are strong theoretical grounds for believing that differences in the liberal and realist variables across countries significantly influence the probability of

[17] Surprisingly, we found no evidence that military dictatorships (Gandhi and Przeworski 2006) spend more on the military, ceteris paribus, with or without D*emocracy* in the specification.

interstate conflict and, hence, national military expenditures. Looking at the difference in conflict probabilities between the United States and Canada in Figure 2 and Table 3, or examining the scatter plot in Figure 3, suggests that these cross-national influences vary substantially and are highly stable for individual countries.[18]

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 stage of the business cycle and other short-term economic factors. To some extent, then, fixed effects may simply pick up Keynesian business-cycle correlations. This is a form of simultaneous equation bias for which it would be difficult to correct. In any event, we are not attempting here to capture the influence of business cycles on military expenditures or the reciprocal influence. The omission of country fixed effects helps exclude these confounding influences.

Despite our reservations, we show estimates of our model of military expenditures with country fixed effects in Table 9. The coefficients for *p-hat* are smaller than when fixed effects are excluded; 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 found that the standard errors of the estimated coefficients of *p-hat* are too large for the results to be meaningful.

Comparing our pooled analyses with those that incorporate fixed effects leads us 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 (pooled) results. 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 period over 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.

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[18] The major difference in the probability of disputes stems from the size variable and its importance in predicting a MID. Also, the US is contiguous with Mexico and with USSR/Russia across Bering Strait. The prediction for Canada probably understates its involvements in disputes because of its alliance with the US.

Conclusions

The present study uses a widely accepted model of interstate conflict derived from the liberal and realist model (LRM) 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 measure of external threat. We focused on a nearly exhaustive sample of 159 countries for the post-World War II period, 1950-2000, but confirmed our findings with analyses of the forty largest countries and fourteen major and regional powers to ensure that our findings applied to these important nations.

Overall, our research provides important external evidence for the validity of the LRM and sheds new light on the determinants of national military spending. Consistent with the normative approach, the degree of threat in a country's external security environment is an important influence on its military expenditures. Indeed, the probability that a state will become involved in a fatal militarized dispute, assessed ex ante by the liberal-realist model, 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 measured by the number of combatants' fatalities, or the military expenditures of friends and potential foes. The chances of involvement in a fatal military dispute vary greatly across countries, and those differences have large substantive effects on countries' 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. Out best estimate is that a one percentage point increase in the probability of a fatal militarized interstate dispute leads to an increase in military spending of between 2 and 3 percent of GDP (other things held constant). Highly autocratic regimes spend much more on the military than do either democracies or mixed autocratic/democratic governments. An increase in military spending by potential adversaries has only a small short term effect on a country, but may produce a 30 percent long term "arms race" effect. The level of national output (measured by real GDP) has a particularly powerful effect, as has been found in earlier studies. There appears to be an important inertial effect in military spending. 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 identify whether the slow response occurs because of political, economic, or capital-stock dynamics.

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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	-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*
GDP relative to world	-0.2120	-0.5390
	0.4350	*0.4330*
Allies	-0.4800	-0.3300
	0.2050	*0.1960*
Ratio of GDP	12.3000	9.6200
	1.3960	*1.2610*
new systsize	-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	-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 GDP	-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	11.7400	11.4200	9.9500	11.9100	11.7200
	2.7370	*1.9840*	*2.5250*	*2.0570*	*1.7130*
new systsize	-0.9690	-1.3870	-1.3140	-0.9290	-1.3850
	0.3790	*0.2450*	*0.3460*	*0.3090*	*0.2460*
_cons	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.

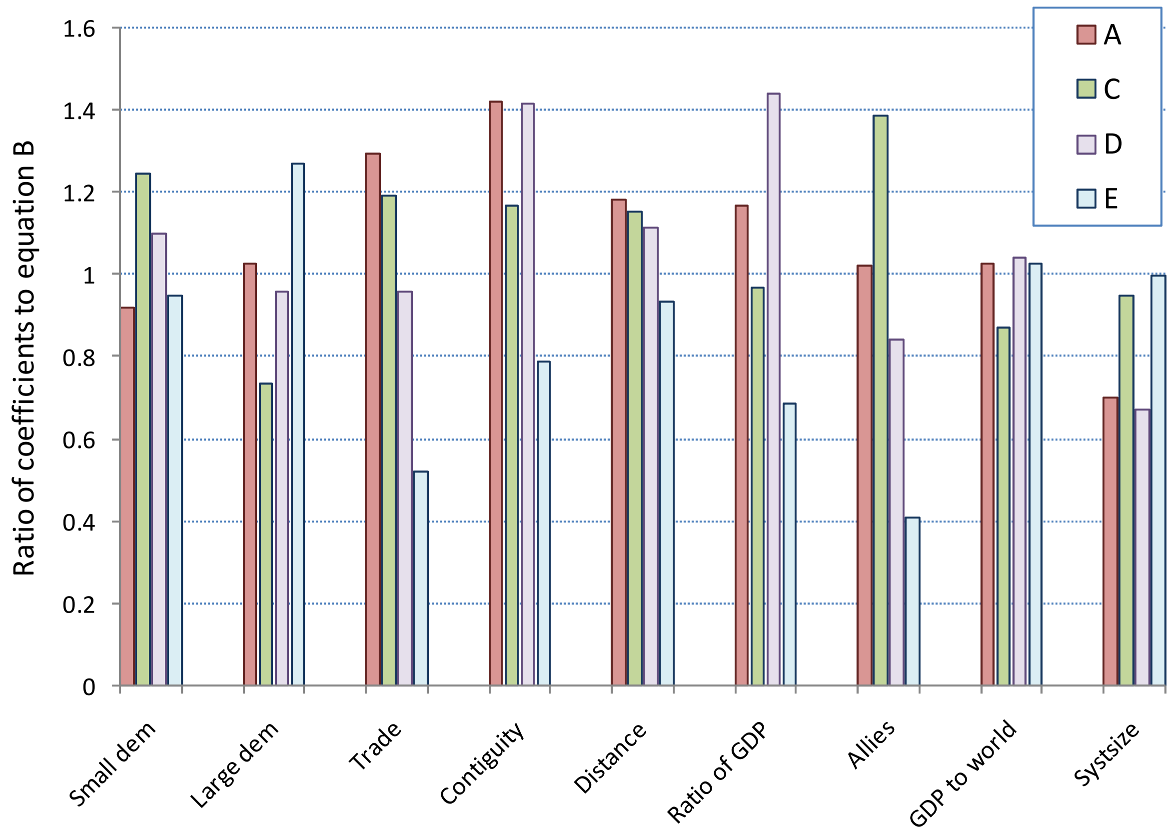

Figure 1. Coefficient stability for equation (1) in Table 2:
Ratio of coefficient in specification A, C, D, or E to specification B

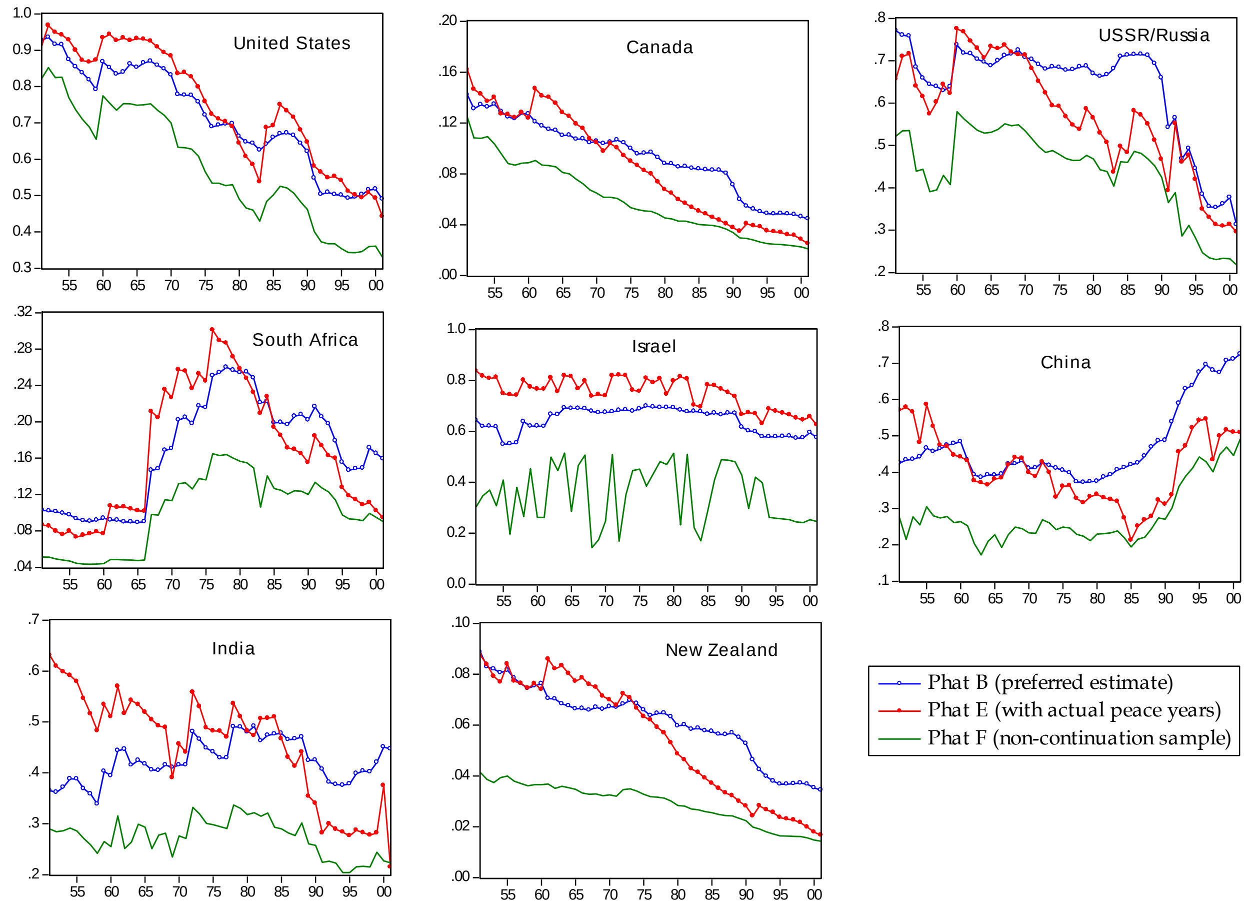

Figure 2. Calculated probability of conflict for 8 major countries, 1950 – 2000

This graph shows the estimated probability of conflict (fatal MID) for eight countries through time. Note the differences in the left-hand scale. These show three different variants. The preferred estimate excludes peace years and uses actual independent variables. The variant with actual peace years has excessive volatility (see Israel), while 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 for Countries with Largest and Smallest Conflict Probabilities

Figures are averages for the period 1950-2000, but begin later for states that gained independence during the period. This calculation omits very small countries such as Singapore and Fijigo.

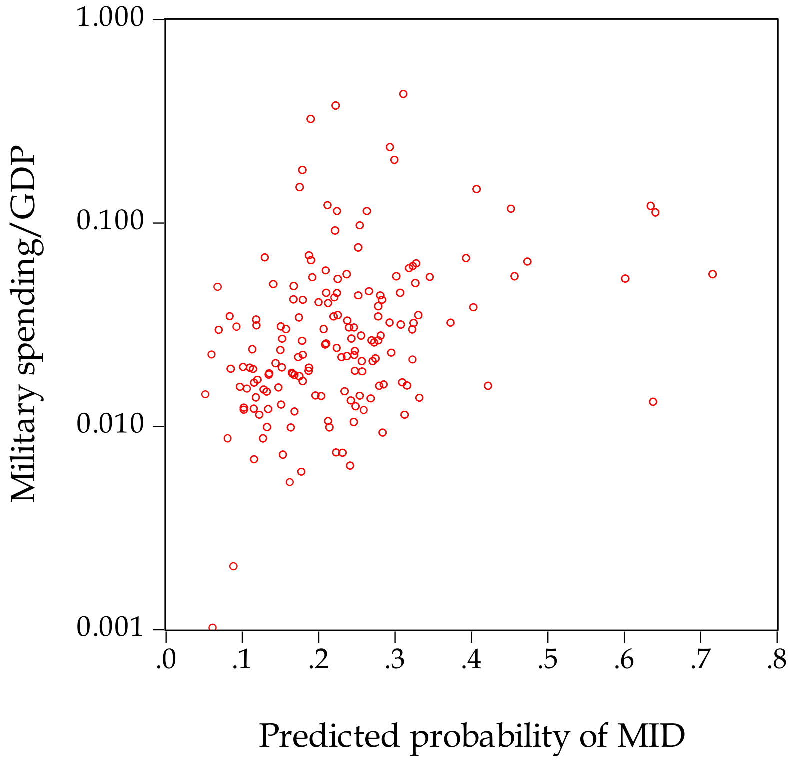

Figure 3. Scatter plot of mean probability of conflict and military spending fraction for each state, 1950-2000

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 for the sample period 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					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	0.622	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. Additional variables are: *p-actual* is the ex post frequency of fatal MIDs aggregated as explained in the text; *Number fatalities* is the number of fatalities of the country divided by 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.)

Appendix. Probability of conflict (fatal militarized interstate dispute) and military spending, ranked by country, 1950-2000

[Note that the probabilities are ex ante ones based purely on cross-sectional estimates of parameters and contain no data on the actual conflict propensity of specific countries. The fact that the US is at the top or New Zealand on the bottom is based on variables such as GDP, geography, political structure, alliance structure, trade, and the like.]

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
United States	71.7	5.5
Israel	64.2	11.2
Congo The Democratic Republic	63.9	1.3
Russian Federation	63.6	12.0
Congo	60.2	5.4
China	47.4	6.4
Yugoslavia/Serbia	45.7	5.3
Jordan	45.3	11.6
India	42.3	1.6
Syrian Arab Republic	40.8	14.5
Turkey	40.3	3.8
German Democratic Republic	39.4	6.6
Iran Islamic Republic of	37.4	3.2
Albania	34.7	5.4
Guinea	33.3	1.3
Lao People's Democratic Republ	33.1	3.6
Saudi Arabia	32.9	6.1
Bulgaria	32.8	5.0
Mozambique	32.5	3.2
Croatia	32.4	6.1
Italy	32.4	2.1
Germany	32.4	3.0
Egypt	32.0	5.9
Cameroon	31.7	1.6
Afghanistan	31.4	1.2
Korea Democratic People's Republic	31.2	37.6
Belarus (Byelorussia)	31.0	1.6
Pakistan	30.8	3.1
Greece	30.8	4.5
Myanmar	30.3	5.4

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
Republic of Vietnam	30.0	20.2
Thailand	29.6	2.3
Sudan	29.4	3.2
Uzbekistan	28.6	1.6
Niger	28.5	0.9
Zambia	28.4	4.1
Azerbaijan	28.3	2.8
Ethiopia	28.2	3.8
Nigeria	28.0	1.6
Cambodia	27.9	3.4
Hungary	27.9	3.9
Tanzania United Republic of	27.9	2.6
Turkmenistan	27.5	2.1
Uganda	27.4	2.6
Rwanda	27.2	2.1
Chad	27.0	2.6
Austria	26.9	1.4
Cuba	26.7	4.4
None	26.4	11.3
Spain	26.0	1.2
Burkina Faso	25.8	1.8
Algeria	25.8	2.1
Denmark	25.7	2.8
Iraq	25.5	9.6
Gabon	25.5	1.4
Viet Nam	25.3	3.8
Romania	25.3	7.5
Sierra Leone	24.9	1.2
Togo	24.9	2.3

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
Benin	24.8	1.9
Senegal	24.8	2.2
Korea Republic of	24.7	3.0
Swaziland	24.7	1.0
Mali	24.4	2.7
Tajikistan	24.3	1.3
Lithuania	24.2	0.6
Equatorial Guinea	24.1	2.9
Armenia	23.9	3.3
Ghana	23.8	2.2
Libyan Arab Jamahiriya	23.8	5.0
Cte D'ivoire	23.5	1.5
Nepal	23.2	0.7
Tunisia	23.1	2.2
Poland	22.6	5.2
Morocco	22.6	3.5
Qatar	22.5	11.2
Lebanon	22.5	4.5
Central African Republic	22.5	2.4
Latvia	22.4	0.7
Bosnia Herzogovinia	22.3	37.5
Bhutan	22.2	3.9
France	22.2	4.3
Cyprus	22.0	3.4
Japan	21.5	1.0
Kazakhstan	21.3	1.1
Norway	21.3	4.0
Angola	21.3	11.1
Zimbabwe	21.1	4.5
Kyrgyzstan	21.1	2.5

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
Kuwait	21.0	5.8
Ukraine	21.0	2.5
Burundi	20.8	3.0
Malawi	20.5	1.4
Liberia	20.1	3.7
Botswana	19.7	1.4
Bahrain	19.3	5.3
None	19.1	5.5
None	19.1	33.0
Djibouti	18.8	6.6
Kenya	18.8	1.9
Macedonia	18.8	1.9
Sweden	18.1	4.1
Finland	18.0	2.2
Georgia	18.0	1.6
Oman	18.0	18.1
Somalia	17.9	2.6
Gambia	17.9	0.6
Mongolia	17.6	13.7
Indonesia	17.6	1.7
Malaysia	17.5	3.4
Luxembourg	17.0	1.8
Haiti	17.0	1.2
Mauritania	16.8	4.8
United Kingdom	16.8	4.2
South Africa	16.7	1.8
Nicaragua	16.6	1.6
Estonia	16.5	1.0
Mexico	16.3	0.5
Portugal	15.8	3.0

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
Bangladesh	15.4	0.7
Dominican Republic	15.3	1.7
Brazil	15.2	1.3
Guinea-Bissau	15.2	3.0
Switzerland	15.1	2.3
Argentina	14.9	1.5
Honduras	14.5	2.0
United Arab Emirates	14.2	4.9
Guyana	13.6	1.8
Ireland	13.6	1.8
Lesotho	13.5	1.2
Jamaica	13.3	1.0
Colombia	13.3	1.5
Taiwan Province of China	13.1	6.7
Slovinia	12.9	1.5
Moldova (Moldovia)	12.8	0.9
Philippines	12.3	1.1
Paraguay	12.1	1.6
Netherlands	12.0	3.1
Belgium	11.9	3.3
El Salvador	11.9	1.4
Costa Rica	11.7	0.7
Bolivia	11.6	1.6
Guatemala	11.6	1.2
Venezuela	11.5	1.9
Uruguay	11.4	2.3
Comoros	11.1	2.0
Sri Lanka	10.7	1.5
Papua New Guinea	10.3	1.2
Panama	10.3	0.9

Country	Probability of conflict (phat), % per year	Military spending/GDP, %
Peru	10.2	1.9
Iceland	10.0	0.0
Madagascar	9.8	1.5
Canada	9.4	3.1
Mauritius	9.0	0.2
Ecuador	8.6	1.9
Chile	8.5	3.4
Trinidad And Tobago	8.2	0.9
Australia	7.0	2.9
Singapore	6.9	4.8
Solomon Islands	6.2	0.1
New Zealand	6.1	2.2
Fiji	5.2	1.4