The Arms Acquisition Process: The Effect of Internal and External Constraints on Arms Race Dynamics

Sean Bolks
Department of Political Science
Rice University
Richard J. Stoll
James A. Baker Ill Institute for Public Policy and Department of Political Science
Rice University

A new approach to address oversights in the traditional arms race literature is presented. It involves five factors that have not been previously applied to arms races. The focus of military capability is not expenditures but weapons counts. The entire set of major powers is modeled as a system. A factor controlling for the level of environmental threat faced by each state is included. Domestic factors are included in the decision-making calculus of the state. It is assumed that states use simple decision rules rather than a complex set of calculations to make their decisions. The authors usc this approach to test a system of equations that model the number of capital ships of the major powers from 1860 to 1986 in different time periods. Results indicate that the overall approach has a good deal of validity.

In May 1998, first India and then Pakistan exploded nuclear devices. Although both countries have since made statements that indicate they will observe a moratorium on future tests, the situation is still dangerous. One major concern is that without a political settlement of the underlying issues between India and Pakistan, these two countries will restart their nuclear competition. This would be dangerous enough because these countries have fought four wars against each other since achieving their independence in 1947.[1] But there are other dangers as well. A dyadic nuclear competition between these two states may have effects beyond their military relationship. India and China have had difficult relations, and an aggressive Indian program to build nuclear weapons may provoke a Chinese response. A Chinese response, in turn, may trigger

1.. Recently, there was renewed combat in Kashmir, an area of dispute between the two countries.

additional activity by Russia, the United States, and perhaps even Japan. It could even create a subsequent impact in India.[2] At the same time, within each of these states, the governments will be pressured by a variety of internal and external factors. The result is a volatile mix, with the actions of one country echoing through others and eventually returning to have an impact on the initial country.

This grim scenario has a marked degree of plausibility. In the post-cold war era, it could occur in any region of the world where a pair of states engages in an intense arms competition. Because of this, it is important to gain an understanding of this type of competition and its impacts. This research examines n-yadic naval competitions among the major powers between 1860 and 1986. We develop a new approach to examining arms races, incorporating a number of different elements drawn from both domestic and international political environments. We use a measure of naval capability that is closely related to the weapons systems of the navy itself-the number of capital ships, rather than a measure based on expenditures. Arms competitions are conceptualized as a system rather than as pairs of states. The national security policy of a state is modeled as responding not only to specific arms competitors but also to the level of hostility in its international environment. A state's ability to meet its national security goals is modeled as being constrained by the total amount of resources avail- able to the state and the need to meet other governmental obligations. Finally, we presume that states use simple decision-making rules to make decisions on foreign and defense policy.

Using seemingly unrelated regression, we model each major power's navy in conjunction with the size of the others. Our results indicate that there is a connection between the naval decisions of the major powers. Furthermore, we find that domestic factors do have an effect, but these are limited when compared with competition and hostility between states.

THE ARMS RACE LITERATURE: A BRIEF REVIEW AND ASSESSMENT

Our study of naval arms competitions is built from the arms race literature. The findings and results of this body of work have been the subject of a number of review articles (McGinnis 1991; Russett 1983; Moll and Luebbert 1980; Rattinger 1976; Anderton 1985, 1989). During the cold war period, arms races were a topic of great interest, and a large number of studies were conducted. For example, Anderton (1989) identified more than 100 published arms race studies using Lewis Richardson's (1960)

2. In a story on a Chinese test of a submarine-launched ballistic missile, the interconnections between military developments in the region were noted: "The prospect of deployment [of the missile) may unsettle some of China's neighbors (sic) and other regional powers such as India. New Delhi cited a perceived threat from China as one of main reasons for its decisions to go ahead with nuclear tests last year" (Kynge and Fidler 1999, 1).

mathematical formulation of dyadic arms races.[3] But despite the great amount of effort that has been invested in the study of arms races, a number of issues arise in the bulk of this work that make it difficult to serve as a simple foundation for our current effort.

PROBLEMS ASSOCIATED WITH ARMS RACE MODELS

Most arms race studies assume that arms competitions are a dyadic phenomenon. This may be true in terms of the direct competition between states. But although individual states may focus on a particular competitor, their buildups can also have pro- found effects beyond the dyad, as illustrated by the discussion of South Asia in the introduction. In turn, the actions of states beyond the dyad may echo back to have an impact on one or both of the dyadic competitors. An exclusively dyadic focus misses these effects.

The arms race literature generally relies on military expenditures (usually total military expenditures) as the measure of military capability. A variety of inherent problems associated with expenditure figures exist. Examples of these problems include the varying elements included in the expenditure number in different nations, the comparison of different data sources,[4] and the pooling of expenditure figures across different branches of the military.

Another weakness in much of the arms race literature is that it ignores the hostility in the international environment that can have an impact on armaments decisions. We see echoes of this in Richardson's (1960, 16) original formulation, with its "motive" constant, that reflects the level of threat from the competitor independent of the level of armaments. More generally, a state's decision about the level of its military capability will be affected both by the military capability of its direct competitors and the level of hostility it faces in the environment. But most arms race studies fail to include a mea- sure of environmental hostility and therefore significantly underspecify the external factors that drive decisions about the level of military capability.

Most studies ignore or downplay internal factors during an arms competition. Of course, Richardson's (1960) equations do include the previous year's military capability of the state in predicting its current capability.[5] But this seems to be a rather sparse and incomplete specification. When policy involves resource trade-offs, it is subject to

3. Richardson's (1960) basic arms race framework specified two equations:

$$\mathbf{M} = kY - aX + g,$$

$$t.Y = LX - bY + h,$$

where for states X and Y. $\mathbf{M}$, $t.Y$ represents changes in each state's military capability; kY, LX represents the impact of the rival's military capability on the state's change in military capability; aX, bY represents the negative impact of the state's own military capability on its change in military capability; and g, h represents "motives" that affect the change in each state's military capability vis-a-vis the other state (in commonplace terms, this may be viewed as the threat perceived by the state from the other state).

4. Lebovic (1998, 1999), Cusack and Ward (1981}, and Goertz and Diehl (1986) each highlight incon-sistencies in expenditure figures across different sources.

5. Interestingly enough, in Richardson's (1960) formulation, the effect of last year's capability was to act as a brake on current capabilities (i.e., the sign of the coefficient is negative). But in many studies, scholars have assumed that the coefficient should be positive, representing the impact of organizational momentum on current capability.

multiple decision-making processes, each one revolving around a group of relevant individuals, and then must undergo some means of aggregation to arrive at a collective outcome (McGinnis 1991, 448). These decision-making processes involve domestic political institutions and structures and frame the political competition for resources. Domestic institutions and social aggregation mechanisms are important determinants of each state's participation in an arms race and should be included in any model of arms competition.

ELEMENTS OF A NEW MODEL OF NAVAL ARMS COMPETITION

We take a slightly different approach to modeling arms competitions given the limitations noted above. Our framework integrates a number of factors from the systemic as well as domestic perspectives. We start with the approach that weapons stockpiles or the numbers of capital ships better reflect naval capability than military expenditures. Rather than focusing on dyadic pairs, arms competitions are conceptualized as reflecting the complete set of the major powers in a realpolitik system. Beyond the direct responses of major powers to their competitors, we presume that each state responds to the level of threat in its international environment. We also model the ability of the state to meet its national security goals as being constrained by the total resources available to the state. States must meet a variety of governmental obligations beyond security. We presume that a state uses simple decision-making rules to make decisions on foreign and defense policy. The next sections highlight each of these factors.

CAPITAL SHIPS

Sea power is a very important component of military capability, allowing a state to project its power and extend its influence far beyond its borders. The number of capital ships is important in the calculations of decision makers when assessing the naval capability balance and/or setting goals for the size of a fleet. The amount of sea power a state possesses, as measured by the number of capital ships it has, should be a major concern of decision makers. We elaborate more on these issues below.

THE MAJOR POWER REALPOLITIK SYSTEM

Decision makers should be concerned about the number of capital ships possessed both by the state's immediate rivals and other significant states with which the state interacts. If we take a group of states that are known to one another and that interact on a variety of dimensions, both as friends and adversaries, we can expect that they will pay close attention to each other's naval capabilities. The major powers (as identified in Small and Singer 1982, 44-45) are such a group;[6] they constitute an interdependent

6. In addition, the major powers possess significant amounts of material capabilities (as compared to the rest of states in the system) and can be expected to have the resources necessary to build capital ships and a significant navy.

system in which each state operates according to the principles of realpolitik. Unfortunately, there is less than a universal consensus about these principles (Cusack and Stoll 1990, 19-62). For our purposes, we will use the description provided by Waltz (1979, 117):

> The elements of *Realpolitik* exhaustively listed, are these: The ruler's, and later the state's, interest provides the spring of action; the necessities of policy arise from the unregulated competition of states; calculations based on these necessities can discover the policies that will best serve a state's interests; success is the ultimate test of policy, and success is defined as preserving and strengthening the state.

Each major power must view all of the rest as potentially deadly competitors. Thus, vigilance about the activities of the others is critical. We therefore expect that each major power will monitor the behavior of the others and evaluate the degree to which its interests are at risk by the actions from the rest of the group; in other words, the major powers are "jealously independent" (Gulick 1955, 4).

We can expect them to exhibit the kind of complex interaction and feedback that we described in South Asia in the introduction. Different pairs of major powers may be engaged in an naval arms competition at the same time, but their actions will be noticed and will influence the naval behavior of other major powers, and their actions, in turn, will have some influence on the behavior of the states involved in arms competitions. To treat only the direct arms competitors, without taking the additional states into account, will result in an incomplete picture of the overall situation.

HOSTILE ENVIRONMENT

In addition to the direct effects of naval competitors and the indirect effects of naval activity by other major powers, there is a third element from the international environment that states operating with realpolitik principles can be expected to observe and act on. This is the amount of hostility directed toward the state. This hostility, whether it comes from direct arms competitors, other states, or some combination, creates an environment of threat to the state. It cannot ignore a significant amount of hostile activity because this may be the precursor of a direct attack on the state or its vital interests. Wolfers (1962, 13) argued that decision makers place a high value on the possession of the state, national survival, national independence, and territorial integrity. His analogy of the house on fire is a fitting one for state reaction under conditions of high hostility: just as all people will leave a house on fire, all states should react to extreme threats with strong-and similar-policy behavior.[7] A few studies (Singer 1958; Cusack 1985; Cusack and Ward 1981; Ward 1984; Oren 1996) include measures of external threat and hostility in their examinations of arms race dynamics. In these cases, the variables do aid in differentiating different environmental effects.

7. There may be differences due to the domestic environment. At high levels of hostility, domestic reaction is likely to be uniform—the house on fire. But if the level of hostility is low, the domestic audience can play a more significant role, either to constrain or exacerbate state actions. Domestic factors will be more fully developed below.

DOMESTIC FACTORS

Our conception of naval arms competition assigns a significant role to domestic factors. The critical features of the domestic environment involve decisions on the allocation of societal resources and the degree of openness of the political system. We begin with the presumption that the state must balance its concern for national security with domestic demands. It does this for several reasons. First, it is the duty of the state to provide for its people, and this necessitates that a significant amount of attention be given to domestic needs, either through government spending to meet those needs or through allowing the people to retain resources to allocate for their own needs. Second, if the population becomes dissatisfied with the allocation decisions of the state, it can act to replace the leadership. Most obviously, this can happen in a democracy through the electoral process. But even if the political system is not democratic, a high level of dissatisfaction among the population can still have a negative impact on the chances of a state (i.e., its leadership) surviving.

One aspect of the domestic environment that plays a role in decisions about naval competition is whether the budget is balanced. Although there were times recently in the United States when the notion of a balanced budget seemed far-fetched, in most eras, a balanced budget was a very powerful force that restrained spending. In general, we would expect that if a state cannot balance its budget, then it would be unable to devote significant additional resources to its navy.

A second aspect is the relative effort devoted to the military. States are endowed with different amounts of basic resources, particularly industrial capacity and people. Given this, states decide to devote a particular share of societal resources to the military. This share can be large, relative to the total societal resources, or small. Although we do not want to use the term *militarized,* we can term some states as having high levels of societal allocation to the military or low levels of societal allocation to the military. High levels of allocation constitute a significant burden on the state and may make a state reluctant to continue to build or maintain a large navy.

The institutional structure of the state can increase (or decrease) its ability to extract resources in a number of ways. The institutional structure serves as a set of formal checks and balances on the decision-making power of leaders. The institutional structure of the state also frames political participation, political competition, and legitimate opposition. Open political systems have greater levels of participation and greater competition for resources. Greater levels of participation and competition lead to a more pronounced opposition to policy (Hagan 1994). In the resource extraction and allocation context (Lamborn 1991), more visible and adverse effects of government tax and spending policies create more intense opposition.

Given their levels of participation and opposition, democratic political systems place a great deal of pressure on leaders to allocate resources very carefully. Domestic audiences are extremely vigilant about resource distribution. As a consequence, leaders in constrained and democratic systems are predisposed to accommodation, bar- gaining, logrolling, and pork barrel efforts to gain and maintain political support. In the arms race context, democratic leaders face significant constraints. Consequently, domestic forces dampen expansion and limit the depletion of resources.

In closed political systems, leaders face fewer constraints and greater policy latitude. In these environments, decision makers are held to be responsible to a cartelized group or oligopoly of elites. Snyder (1991) depicts these groups as having greater ability to influence policy than comparable groups found in more open systems such as democracies. He concludes that systems holding these characteristics are much more attuned to undertaking more extreme policy approaches such as those associated with state expansion.

SIMPLE DECISION-MAKING RULES

We conceive of states making their decisions by applying simple decision-making rules. This approach is most commonly associated with the so-called Carnegie Mellon school (Cyert and March 1963; Simon 1969), but there are plenty of other echoes of this approach in the international relations literature. For example, Braybrooke and Lindblom (1969) argue that incremental change in policy is likely when small changes are at stake and there is a high level of understanding. In a naval arms race, we assume that states generally have clear, explicit, and simple goals. In most cases, we assume that states seek parity against their competitors (or perhaps parity plus a bit more), although we are open to other goals if there is reasonable evidence for these in the historical record.

WHY NAVAL ARMS COMPETITIONS? WHY SHIP COUNTS?

Most studies of arms competitions use total military expenditures as their measure of military capability. Our approach will be quite different. We need to justify why we reject exploring arms competitions through the use of total military expenditures, why we choose to separate out the naval aspect, and why we will use a ship count as the dependent variable rather than naval expenditures.

TOTAL MILITARY EXPENDITURES: THE PROBLEMS

Using total military expenditures is often not a good measure of the arms competition between states for several reasons. Expenditures are certainly the most commonly used measure of military capabilities. They are frequently used because they appear to provide a single comprehensive measure of capability that obviates the need to make judgments about quality and how to combine disparate elements (personnel, equipment, etc.) together. Despite the understandable attractions of an expenditure measure, a number of problems are associated with this approach. First, it does not take into account that some countries rely on conscription, whereas others have a professional military. The result is that personnel costs can vary widely and a comparison of expenditures between states with different personnel policies can be very misleading.

A related problem is that states do not have the same concept of what properly is to be considered military expenditures. For example, states can treat pensions for retired

military personnel in very different ways. Of course, spending on pensions does not contribute to military capability, but if some countries allocate all pensions to the military budget and others allocate little of their pensions to the military budget, this is another source of incompatibility between defense budgets.

Another problem involves the comparison of expenditures between states with different economic systems and/or very different economic policies. For example, the problems of comparing expenditure figures of any sort between a free market economy and a socialist economy are well-known. A less obvious problem is that different countries have adopted different policies about subsidizing military industries. This can result in a significant reduction in military expenditures, although the difference may appear in other parts of the government's budget (i.e., where the subsidies are allocated).

A fourth problem can occur if states engage in deliberate deception about the level of their expenditures. It was not too many years ago that there was an entire cottage industry devoted to estimating the military expenditures of the Soviet Union. Various positions were staked out in the debate as to how much the Soviets really spent, but virtually all participants agreed on one point: the officially reported Soviet figure deliberately underestimated the real level of expenditures.8 In the opinion of some analysts, this sort of deception did not end with the cold war. Recently, a pair of analysts argued that the real level of Chinese military expenditures is at least 10 times higher than the official figure given by the Chinese government (Bernstein and Munro 1997).

Total military expenditure implies that all of the armed services of the states are engaged in the competition; in fact, it implies that a dollar spent on one military service can substitute for a dollar spent on any other military service. The connection between military expenditures and military capability may be weaker than is generally assumed, and better measures of military capability are available.

If two states are rivals, they will be concerned with the balance of military capabilities between them. But this does not necessarily mean that all the armed services of the rivals are equally engaged in the arms competition. Most arms competitions feature only a single service. This was recognized in Huntington's (1983) classic article on arms races. He identifies 13 arms races between 1840 and 1958. In each case, Hunting- ton identifies the race as naval, land, air, or nuclear. No race on his list is given more than a single category. As he notes,

8. One incident during this long-running debate illustrates how loose the linkage between expenditures and military capability can be. In the mid-1970s, a number of conservative defense analysts felt that the CIA was underestimating the expenditures, capability, and malign intent of the Soviet military. The director of the CIA convened the so-called Team B, a group of these conservative analysts who were cleared for access to the same information that the CIA used to make its estimates. Team B concluded that the CIA had greatly underestimated Soviet expenditures. Shortly after this, the CIA revised its estimate of Soviet spending upwards by 100% (Lee 1977). But the revision of expenditure figures was not accompanied by any revised estimate about the size, number, or quality of Soviet forces. Thus, the actual military capability of the Soviets did not change after the revision. In effect, the CIA changed its accounting rules and decided that the Soviets were twice as inefficient in producing and maintaining their military forces than was estimated previously. We take no position on which set of CIA figures is "better" but simply assert that the fact that such a drastic revision could have happened suggests that the use of military expenditures as an indicator of military capability should be done with more caution than is usually the case.

> Even if both parties to an arms race possess similar land, sea, and air forces, normally the race itself is focused on only one of these components or even on only one weapons system within one component, usually that type of military force with which they are best able to harm each other. (P. 447)

Consider Britain and Germany at the turn of the century. British concern about Germany caused it to settle its foreign policy differences with both France and Russia and to form alliances with both. Any scholar of international relations knows that a great deal has been written about the naval arms race between Britain and Germany that most date as running from 1898 to the outbreak of World War I,[9] but what about the arms race between the British and German armies? We understand if readers stifle a laugh in pondering this question. It seems clear that the Germans gave little, if any, serious consideration to the British army. The British did consider the threat of the German army, at least in the sense of developing plans to transport the entire British army to France in the event of a war with Germany. But one would be hard-pressed to argue that there was an overall arms competition between the two countries. One will be equally hard-pressed to argue that there was not an intense naval competition between them. It seems clear that the use of total military expenditures to track this Anglo-German naval race would be inappropriate.

This example suggests that when states are engaged in a serious rivalry that includes an arms competition, treating that competition as involving all the military services does not usually make sense. An arms competition may not involve all the armed services of two states (as in the Anglo-German naval arms race). Even if more than one service is involved (as in the U.S.-Soviet nuclear and naval competitions during the cold war), using total expenditures implies that any service is a complete substitute for any other service (i.e., a dollar spent on the navy is the same as a dollar spent on the army).[10] But the existence of a degree of substitutability does not justify the assumption of complete substitutability that is implicit in the use of total military expenditures in studies of arms competition.

The implausibility of complete substitutability across all the military services leads us to the conclusion that the study of single military service arms competitions would be worthwhile. Having argued that it would be beneficial to orient a study of arms competitions around a single service, which orientation should we select? Returning to Huntington's (1983) categorization of arms races-naval, land, air, and nuclear-we believe that the study of naval arms competitions is the most fruitful. We wish to study a series of competitions through an extended period of time, and the number of air and nuclear competitions is somewhat limited due to the relatively recent development of both these types of weapons systems. In addition, as we noted above, we wish to study how arms competitions affect states beyond the direct competitors. If we studied either air or nuclear competitions, our ability to do this would be limited because of the time

9. Huntington (1983) himself believes that that arms race ended in 1912.

10. Of course, there is some overlap; the U.S. Navy, Air Force, and Marine Corps all fly some of the same types of aircraft (e.g.• fighters, fighter-bombers, and tankers) and can undertake similar missions. In addition, some weapons systems can substitute for others (cruise missiles can substitute in some situations for strikes by manned aircraft).

periods when only a few states possessed the ability to build and deploy air or nuclear weapons systems. At times, not even all of the major powers could participate in these arms competitions.

There is also a substantive reason to study naval competitions. A navy can be used to project military power well beyond the borders of the state. Until the rise of airpower, navies were the only way to project military power. Even today, large navies retain a significant ability to project power. In the words of Modelski and Thompson (1988, 13),

> It is a fundamental postulate ... that seapower (or, more precisely, ocean power) is the *sine qua non* of action in global politics because it is the necessary (though not the sufficient) condition of operations of global-that is, intercontinental-scope.... Seapower is not an immutable and unalterable ingredient of capacity for world-wide operations. Its relative weight could decline. But over the entire experience of the modern world since 1500 it has proved decisive in facilitating global coordination and it will remain decisive as long as it continues to do that.

MEASURING NAVAL CAPABILITY

We do not want to argue that military expenditures are useless and should never be used as an indicator of military capability. But the problems we have enumerated do exist and, in our opinion, make the case to explore the utility of alternative indicators of military capability. After all, wars are not fought with currency but with weapons and people. Past studies by Ward (1984), Stoll (1992), and Lambelet (1974, 1975, 1976) have used weapons stockpiles to model arms races. They provide good examples of approaching military capability from a perspective other than military expenditure.

We choose to focus on the count of capital ships as a measure of naval power (Modelski and Thompson 1988). By the phrase *capital ship,* we mean the type (or types) of warship(s) that possess the greatest amount of naval combat power. Alternative measures to expenditures include tonnage and firepower. Ship counts are a better indicator. One reason is that (with a few caveats) it is a simple measure to compute. But more important, there are a number of documented instances in naval history in which it is clear that states were focused on ship counts to weigh the balance of naval forces. We offer a few examples of ship counts to estimate the balance:

- In 1904, the British government convened a special admiralty committee to study the two-power standard (the goal of the British navy to be as large— perhaps a bit larger- than the next two largest navies). The conclusions of this committee were expressed in terms of numbers of battleships (Marder 1961, 124).
- On November 22, 1890, the French Superior Council (their version of the admiralty) approved the French naval budget with the statement that "the combatant units of the French fleet must be equal in number to those of the combined fleets of the Triple Alliance" (Ropp 1987, 197).
- Between 1907 and 1922, the Japanese navy desired to have its so-called 8-8 program. This program specitied a fleet of eight modern battleships and eight modern cruisers to have a navy 70% the size of the U.S. navy. This goal was derived from Japanese studies,

which concluded that if the smaller fleet was 70% of the larger fleet, the larger fleet could not defeat the smaller fleet (Evans and Peattie 1997, 143, 150).

- A fourth example of ship counts as goals occurred during the Reagan administration's naval buildup of the 1980s. With a great deal of publicity, the proclaimed goal was a 600-ship navy.

In the words of Ward (1984, 298), "Simply put, weapon stockpiles are too important to be ignored in evaluating a rival's potential threat and should be included in any attempt to understand arms races."

ESTIMATION ISSUES

Two estimation issues must be addressed. One concerns the proper econometric technique to be used. The other issue (which is related to the first) concerns the nature of the dependent variable.

Consider naval decisions among the major powers. Some factors in the international system are common to all major powers (e.g., occurrences of conflict in the international system are expected to have an impact on all major powers), but others are specific to each state (e.g., the specific naval competitors of a state). At the same time, the domestic political environments and decision makers' abilities to allocate resources may vary across nations. Finally, the ripple effects of a state's armaments decision may echo through the entire set of major powers. Given all this, it makes sense to consider the arms development process of states jointly.

Past econometric work (Zellner 1962; Zellner and Huang 1962; Judge et al. 1985; see Greene 1993 for a discussion) concludes that estimation of equations jointly adds additional information and increases the efficiency of the estimation processes. The greater the correlation of the disturbances, the higher the level of accuracy produced by the joint estimation. At the very worst, if the equations are unrelated, the results are the same as ordinary least squares (OLS) estimates. We base our estimation on a system of equations approach developed by Zellner (1962), known as seemingly unrelated regression (SUR). This method applies feasible generalized least squares to estimate a covariance matrix of the disturbances and gain residuals. Zellner's SUR is "asymptotically more efficient than the former [single-equation estimation] if the error terms of the equations are contemporaneously correlated" (Zellner 1962, as quoted in Mintz and Huang 1990, 1287). This technique also allows us to estimate the degree to which the residuals of the equations are related by examining the residuals across the equations. By employing the Breusch and Pagan Lagrange multiplier statistic (distributed as a chi-square measure), one can calculate a significance level for the correlations.

SUR is the most appropriate technique, but this still leaves us with one issue: the nature of the dependent variable. As alluded to above and discussed more explicitly below, the dependent variable for each equation is the count of capital ships. Because of the properties of a count variable, it is not completely appropriate to use SUR, which

assumes (like OLS) that the dependent variable is continuous. Unfortunately, there is no simple solution to this problem. King (1989, 201-7) develops a SUR model with count variables as the dependent variables, but his technique can only accommodate two equations. After some discussion (King, personal communication, 1999; Ensor, personal communication, 1999), we decided to transform the dependent variable ship counts by taking the square root. The square root is the variance stabilization transformation for the Poisson. This should minimize the estimation problems.

SPATIAL TEMPORAL DOMAIN

In our research design, we examine two periods between 1860 and 1986: 1860-1939 and 1946-1986.[11] The individual periods reflect the entrances and exits of major powers in the international system. In the period from 1860 to 1939, we examine Great Britain, France, Russia, Germany, Italy, Austria-Hungary, Japan, and the United States. Although Japan and the United States are not considered major powers until the 1890s, we feel that they did have an impact on the major power system and naval com- petitions prior to this date. The second period is post-World War II and includes the United States, the Soviet Union, France, and Britain. We chose not to include China, a major power from 1950 to 1986, because China had not developed a significant navy over a prolonged period of time.

OPERATIONALIZATION

DEPENDENT VARIABLE

Our dependent variable is the count of capital ships held by major powers in each year. Our rationale for using capital ships and the definition of the concept were discussed above. The ship counts are taken from Modelski and Thompson (1988). As noted above, we transform the dependent variable by taking the square root. When appropriate, we incorporate two dummy variables in the analysis for the time periods from 1880 to 1909 and 1910 to 1913. The dummy variables are incorporated to account for the changing definition of what constitutes a capital ship in Modelski and Thompson's data set and the possible impact of this change (i.e., the consequent drop in the count of ships for all countries) on the results.[12]

11. We exclude both of the world war periods because the arms competitions that took place during the world wars were fundamentally different from what takes place in peacetime.

12. After World War II, Modelski and Thompson (1988) count three different types of ships as capital ships: large aircraft carriers, nuclear-powered attack submarines, and ballistic missile-carrying submarines. Because we analyze this period separately, there is no need for an additional dummy variable. Note also that we exclude ballistic missile-carrying submarines from our ship counts. Although these are naval vessels-and certainly very powerful weapons platforms--they are more properly considered to be part of the cold war strategic arms competition, not the conventional naval competition.

VARIABLES FROM THE INTERNATIONAL ENVIRONMENT

Three variables-hostility, competition, and war-are included to model the relationship between each major power and other actors in the international system. The hostility variable is a proxy measure for the state's assessment of how the external environment impinges on its national security. Conceptually, this variable is a reflection of the conflict and potential conflict facing each state in each year. The hostility variable is constructed from a rolling 5-year period of dispute participation, taking into account the location and capabilities of the dispute opponents and the historical legacies associated with long-term conflictual relationships. These are aggregated into an ordinal scale. The appendix contains a complete description of the operationalization of this variable.

A competition variable is used for individual states when they are judged to be in a naval arms competition. It is a count of the number of capital ships held by the state or states with which the state has a naval arms competition. A variety of historical sources were consulted to identify competitors and time periods. A list of competitors for each state is given in the appendix. In most cases, the major powers used the simple decision rule of maintaining the number of their capital ships as a function of other states. Typically, the rule used is one of parity. However, Great Britain sought a two-power standard over the next two biggest navies in the system in some years, whereas Germany and Japan sought to maintain a navy that was two thirds the size of another navy in the system.

A dummy variable for war is included if the state was involved in an interstate war in a given year. We include the variable because it may have a significant effect on naval construction (and destruction) and the national debt. We also include two dummy variables for the impact of interstate war wins and losses on the size of the navy. In each case, we code a dummy variable for 5 years after an interstate war victory and a second dummy variable coded for 5 years after an interstate defeat. We are not convinced that all major powers will react in the same way to victories or defeats, but we do believe that these are watershed events and may exercise a significant effect on subsequent naval construction. Thus, the war variables are included as control variables, not substantive variables.

A final variable is the lagged number of the state's capital ships. This is included for two reasons. First, it offers a reflection of the bureaucratic momentum of a state's propensity to continue to build ships. Second, it eases the effects of serial correlation in the analysis.

VARIABLES FROM THE DOMESTIC ENVIRONMENT

Three measures are included to account for the domestic political processes and environment of each state: institutional constraint, deficit, and the relative allocation of resources to the military. The institutional constraint index was created by Maoz and Russett (1993) from variables in the POLITY II data set. It captures the loci of political power within different institutional structures and its effects on a wide scope of economic and social life. This index taps the institutional checks and balances placed on

leaders, the centralization of political power as distinguished by unitary and federal polities, the scope of governmental action on citizens' lives, and the degree of one-person rule found in the political system. Conceptually, the variable is a reflection of the complexity of the policy implementation process and how leaders are constrained in their policy efforts.[13] As we noted above, the greater the institutional constraints on the state, the Jess its ability to allocate resources to the navy.

The second measure is a deficit variable. Deficit reflects the total government expenditures of that year subtracted from the total government revenues. As discussed above, we hypothesize that decision makers in highly competitive political systems face two difficulties: (I) they may face punishment if they extract high levels of taxes, and (2) they face higher levels of constraint in the resource allocation process itself. Given the high opportunity costs of building capital ships, we expect that leaders will have to extract higher levels of resources or go into debt to construct a significant navy, and when they do run a debt, this may adversely affect their ability to build additional ships. We measure deficit in an extremely simple fashion. It is the deficit divided by revenues. Thus, it takes on positive values when the state experiences a deficit and negative values when it experiences a surplus.

The final measure is the relative allocation of resources between military and nonmilitary dimensions in a state. We begin with the familiar six indicators of capability introduced by Singer, Bremer, and Stuckey (1972): military expenditures, military personnel, iron or steel production, commercial energy consumption, total population, and urban population. We first convert each raw indicator into the systemwide proportion held by the state (i.e., if the total number of military personnel in the world is 1,000,000 and a state has 1OO,OOO personnel, its percentage score is .1). We then create a score for the military, industrial, and population dimensions by taking the average proportion for each pair of indicators (i.e., the military dimension is the average proportion of the military expenditures and military personnel).[14] The allocation ratio is the military dimension, divided by the average of the industrial and population dimensions. Scores of more than 1 indicate that the state has a higher proportion of the system's military resources than of the system's industrial and population resources; scores of Jess than 1 indicate the opposite.

LAGS

Because it takes time to build ships, governments make decisions this year with current information, and these decisions will not be reflected in the size of the fleet until sometime in the future. An examination of the British navy during the bulk of the time period under study (Parkes 1990) shows that the typical time period for construction of

13. The specifics of this indicator are described in the appendix. There is a close relationship between institutional constraint and democratic score. We chose to employ the institutional constraint variable because it more accurately reflects how resource allocation decisions are made within and across different types of states as compared to the democratic score variable.

14. If the state has missing data for one pair, the dimension score is the proportion on the nonmissing indicator.

a capital ship was about 3 years. In the post-World War II era, the average rate of construction for an attack submarine of the *Los Angeles* class was about 3.8 years (calculated from Sharpe 1996, 798).[15] When predicting the number of capital ships in year t, we lag all the variables in the equation by 3 years except the dummies for year (reflecting changes in the coding of what is a capital ship) and the war variables.[16]

RESULTS

We will discuss the two periods separately. We devote most of our attention to the impact of the international and domestic variables, as well as comment on the degree to which the equations are related.

1860-1939 TIME PERIOD

In the first time period, we estimate a system involving the navies of the United States, Britain, France, Germany, Austria-Hungary, Italy, Russia, and Japan.[17] During the first 20 years of this period, there was a great deal of uncertainty about the characteristics of the ideal capital ship; should the emphasis be on guns, armor, or the ram? In addition, some argued that the mine or the torpedo rendered capital ships obsolete. But by 1880, there was general agreement on the characteristics of a "standard" battleship. It would consist of fairly heavy armor; two turrets, each with a pair of 12-inch guns; and a top speed of perhaps 18 knots. Note that there was little or no actual naval combat during that period, which made it difficult to sort out the proper characteristics empirically. The definition of a capital ship changes again with the completion of the *HMS Dreadnought* in 1906. By 1910, it was clear to all the navies of the world that only dreadnought-type ships could be considered capital ships.[18]

15. We chose the *Los Angeles* class because a large number of units were built (58); therefore, we could obtain a stable estimate.

16. We also ran the results with a lag of 4 years for all the substantive variables. The results do not differ significantly from the results of the 3-year lag.

17. Not all these states were major powers for the entire period under study; Japan is not considered to be a major power until 1895, the United States is not considered a major power until 1898, and Austria-Hungary is eliminated from the system after World War I. Furthermore, Germany and Russia are absent from the major power system for several years after World War I (see Small and Singer 1982, 44-45 for a discussion of the major powers). But if we do not put all these states into the system of equations, then we must break down the estimation into several smaller series of years, which, given the large number of variables in the equation, creates problems. This would also result in breaking up some arms competitions and placing them in several estimations, which is also undesirable. Compared to these problems, we believe that the downside of including the three nonmajor powers is minimal. For most of the period prior to joining the major power club, Japan and the United States have few or no capital ships and are not engaged in arms competitions with other major powers. After World War I, we code a value of 0 for all variables in the Austro-Hungarian equation. Note also that we code missing data for World War I and end our analysis before World War II because we believe that arms competitions during the world wars are of a fundamentally different nature.

18. After World War I, navies began to build aircraft carriers, but it was not until World War II that these ships superceded the battleship as the capital ship.

TABLE I

Predicted Number of Capital Ships, 1860-1939

	Britain	*France*	*Germany*	*Italy*	*Russia*	*United States*	*Japan*	*Austria-Hungary*
Hostility	.02	-.02*	.08*	.02	-.03*	.07*	.02	.03
	(1.62)	(1.96)	(3.16)	(1.91)	(4.35)	(3.40)	(1.24)	(1.36)
Deficit	1.04	-3.99*	-.18	.65	.40	1.76*	.16	.26
	(.97)	(4.30)	(61)	(1.43)	(1.48)	(3.11)	(.62)	(.72)
Institutions	-.29	.02	.78	.04	−.56*	−.06*	-.73*	.14*
	(1.61)	(.14)	(1.19)	(.57)	(5.24)	(198)	(4.80)	(3.35)
Ships	.01	-.19	.13	−.01	−.11	.18	.10	.55*
	(.11)	(1.82)	(1.05)	(.05)	(1.76)	(.92)	(76)	(2.73)
War involve	-.81*	-.16		−.14	.32*	.10	-.21	
	(2.17)	(1.06)		(45)	(3.99)	(.25)	(.66)	
Win war	−.94*	.42*	.02	.62	.38*	.31	.12	
	(3.41)	(2.54)	(.01)	(1.74)	(3 78)	(1.15)	(.40)	
Lose war		-.29			−.0J			
		(.42)			(.06)			
Dummy: 1880	-.96	-1.54*	-1.61.	1.19	-2.94*	.57*	-1.71*	−.12
	(1.71)	(2.86)	(3.49)	(.52)	(22.29)	(2.01)	(6.94)	(58)
Dummy: 1910	-1.71*	-4.1I*	.34	−.51	--4.16*	1.45	-3.75*	-1.29*
	(2.13)	(5.15)	(.41)	(.22)	(26.87)	(1.73)	(4.72)	(2.54)
Competitor	.II*	.02	.08*	.16	.02*	.07*	−.05	.21*
	(5 58)	(1.72)	(5.73)	(1.17)	(4 19)	(4.57)	(1.18)	(2.94)
Allocation	3.33*	.73*	2.28	.98*	−.26*	1.30	.46*	−1.36*
	(5.99)	(2.52)	(1.70)	(6.85)	(2.61)	(.96)	(2.61)	(3.42)
Constant	7.74	3.39	-13.61	-2.18	11.99*		16.02*	
	(187)	(1.05)	(1.22)	(.76)	(10.03)		(5.25)	
R2	.91	.94	.79	.89	.98	.92	.83	.81
/	447.84	618.48	154.11	335.98	1676.88	1043.50	197.00	241.07
n	39	39	39	39	39	39	39	39

NOTE: Numbers in parentheses are *z* scores.

*Significant at the .05 level. Chi-square for Breusch-Pagan: 38.14, $df = 28$, $pr = .09$.

Overall, the fit of the individual equations is good. The weakest fits are for the smallest navies (i.e., the navies with the smallest average number of capital ships through the entire period under estimation). This is more than a statistical issue (i.e., that the lack of variance in the dependent variable will tend to decrease the fit). All four of these countries went through extended periods of time in which they had no naval policy and hence no capital ships. The premise of our approach is that navies are an important, even critical, governmental resource. If a state does not view a navy as important,[19] it is unlikely that the size of the navy will be well specified by the set of factors in our model.

19. For example, the earliest commanders of the Prussian (then German) navy were generals from the army who had little appreciation for the unique qualities of navies.

International variables. The arms competition variable is positive for seven of the eight major powers. It is insignificant for Italy and France, but the significance level for the latter is .08. The negative (although insignificant) coefficient for Japan is due to several factors. First, Japan begins to build capital ships before it has a competitor (i.e., the competitor variable is 0). Second, the treaty produced by the Washington Naval Conference of 1929 limited Japan to a navy that was 60% of its rival, the United States. The competition variable generally performs as we expect with a positive and significant coefficient in five of the major powers.

Six of the major powers respond positively to hostility from the external environment, although it is only significant for the United States and Germany (although the significance of the coefficient for Italy is .06). The insignificance for Britain is due to the fact that the size of the British navy varies systematically through time; it tends to grow. But the hostility faced by Britain, although positively related, fluctuates a lot through time and produces a statistically insignificant relationship. Japan's insignificant relationship is due to a combination of a period of time when Japan had no navy but a fluctuating threat and the systematic growth of the Japanese navy that coincides with a fluctuating level of hostility. The reason for an insignificant relationship for Austria-Hungary has more to do with the extended period of time (1860-1901) in which Austria-Hungary was faced with a fluctuating threat but had no capital ships. In addition, we see Austria-Hungary, France, and Russia as more oriented toward land power than sea power. Although we did not explicitly examine this question, we believe it likely that these three countries were more likely to respond to hostility by increasing their armies rather than their navies.

Domestic variables. The institutional constraint variable has a mixed effect. It is positive for four of the major powers and negative for four of the major powers. If we focus on coefficients that are statistically significant (a total of four), three are negative (as we expected) and only one is positive. We do note, however, that for most countries, there is little change in the value of this variable through the time period, and this lack of variability may contribute to the insignificance of some of the coefficients.

Although only two coefficients for the deficit variable are significant, six of the eight are positive. That is, most major powers in this time period were willing to run a deficit to build a large navy; a deficit did not serve as a brake on naval expansion.

The one variable representing a domestic factor that does have an impact is the military allocation variable. It is significant for five of the eight major powers and is pre- dominantly positive. Although the results for the allocation variable are stronger than for the deficit variable, they point to the same conclusion. Higher levels of allocation to the military are associated with larger levels of naval power. Thus, high levels of allocation to the military do not serve to brake the growth in navies.

Finally, we examine the Breusch-Pagan test of independence for the system of equations. The significance of the chi-square value indicates that there was a high degree of interdependence between the major powers in this time period. This result is in accordance with our expectations and validates our approach to the study of major power naval competitions.

Stepping back from the individual coefficients, we now look at the broad pattern of the results. During the time period from 1860 to 1939, there were several changes in what constitutes a capital ship and a large number of changes in the naval arms competitions. But throughout this time period, the decisions of the major powers on the size of their navies were driven primarily by external factors. There is a braking effect for some countries that were under institutional constraints. But large deficits and large allocations of resources to the military do not lead to small navies; rather, they are associated with large navies.

1946-1986: COLD WAR COMPETITION

The cold war competition between the West and the Soviet Union had a naval dimension as well. But this was a different type of naval competition. It featured two types of naval capital ships: aircraft carriers and nuclear-powered attack submarines.[20] In addition, there was a significant asymmetry in the competition; the Western navies all built aircraft carriers as well as submarines, whereas the Soviet navy built only submarines during the years of this study.[21] It has always been a matter of controversy as to whether the Soviet navy was built to challenge the American navy on the open seas or whether it was built to defend its ballistic missile submarines in a series of bastions close to its home waters (Herrick 1968). As noted above, due to the higher level of secrecy, we lag the competitor variable in this analysis. Note that we do not code Britain or France as being part of any naval competition during the time period. Overall, the fits for the individual equations are good, particularly for the Soviet Union and the United States. This makes a good deal of sense substantively; although there is debate as to the nature of the relationship between the U.S. and the Soviet navies, there is no question that both navies were important aspects of their countries' national security policy.

The impact of international variables is weaker in this period. Arms competition is positive and significant for the United States but not significant for the USSR.[22] Hostility often has a negative impact. Institutional constraint is positive for all three democracies (although only significant for one), but the deficit has a negative (but insignificant) impact for these same democracies. Resource allocation has a mixed impact. Overall, the picture is one of more varied responses than in the earlier time periods. Finally, the Breusch-Pagan test of independence for the system of equations and the correlation matrix of residuals (probability of .04) strongly supports the proposal that the naval decisions of the major powers are linked together into a single system.

20. As noted in note 12, we exclude ballistic missile-firing submarines from our analysis.

21. China is omitted from this analysis. They have no capital ships until 1979 and reach a maximum of three (all nuclear-powered attach submarines) in 1986. The small numbers are indicative of the fact that China was not considered a serious naval power in this time period.

22. This is consistent with the argument that the Soviet Union built its navy to operate from bastions. rather than to challenge the U.S. navy on the open sea.

TABLE2
Predicted Number of Capital Ships, 1946-1986

	Britain	*France*	*USSR*	*United States*
Hostility	-.03*	-.01	-.12	-.01
	(2.72)	(48)	(.II)	(.67)
Deficit	-1.29	2.07*	--6.01	–.16
	(2.05)	(5 OJ)	(1.81)	(.54)
Institutions	-.41*	–.02	.*50**	-.50*
	(3.56)	(.99)	(5.68)	(5.49)
Ships	1.09*	.15	.59*	.07
	(9.77)	(1.05)	(6.52)	(.56)
War involve	-.34*	-.31*	-1.99*	-.01
	(2.49)	(1.98)	(5.67)	(.04)
Win war	-.24*	-.76*	1.01*	–.38*
	(2.04)	(627)	(3 5I)	(2.39)
Lose war				.18
				(1.50)
Competitor			.02*	.02*
			(2.51)	(6.16)
Allocation	1.02	.60*	-1.54*	1.22*
	(1.52)	(3.18)	(3.74)	(4.57)
Constant	5.83*	.93	3.97	11.52*
	(3.65)	(1.94)	(1.71)	(6.35)
R2	.91	.77	.99	.99
/	337.56	109.98	6150.35	3709.89
"	31	31	31	31

NOTE: Numbers in parentheses are *z* scores.
*Significant at the .05level. Chi-square for Breusch-Pagan: 14.35, *df*= 6, *pr* = .03.

DISCUSSION

As we compare the domestic and international variables both within and between the time period, several conclusions are suggested. First, taken as a set, the domestic variables are less potent than we expected. The exception is the institutional variable, which increases in importance as a brake on naval expansion through time. Second, consider the impact of the hostility variable and the relative allocation variable. Looking across the time periods, the impact of both variables declines. This suggests that initially there was a tight connection between the foreign policy environment (the level of hostility), overall decisions about the amount of resources to allocate to the military, and the size of the navy. But through time, decisions about the size of the navy became somewhat detached both from the external environment and from overall decisions about resources to allocate to the military. Third, whether embodied in the Breusch-Pagan test or simply the correlation among residuals from the individual equations, there is a connection between the naval decisions of the major powers.

CONCLUSION

We began this study by offering a plausible scenario for the future of Asia. Our story implied a series of connections between apparently distinct competitions, as well as the impact of domestic factors on each state's armaments decisions. We began with this notion and used it to build a model of naval competition between the major powers. We felt that examining naval competitions would help us understand current and future arms competitions. After conducting this examination on great power naval competitions from 1860 to 1986, our basic conception has been validated. States do respond to the actions of their competitors, but they are subject to a variety of interconnections that lead to decisions about the size of navies. Studying arms competitions is important, but we hope that our results will point the way to a more sophisticated approach to these studies.

APPENDIX
Variable Discussion

HOSTILITY

The index is created by summing the dispute participation across time as developed by Bolks (1999). A rolling 5-year block of time is used to determine a base level of hostility for all states. This baseline focuses on the highest hostility level faced by a state within each dispute in which it participated. Hostility levels are identified in the participant data of the militarized interstate dispute data set. For a thorough investigation and development of these data, refer to Jones, Bremer, and Singer (1996). Here, a 5-point ordinal scale codes the significance of each dispute action. The lowest level, 1, reflects the occurrence of an action without a precise coding of the action-these actions were coded as -9 originally. We made a decision to include these actions as the lowest value of hostility. The inclusion provides more data and is unlikely to bias any analysis given the lowest demarcation (any bias will be against the development of threat rather than for threat development). The highest level, 5, reflects a war directed at the state. The hostility scores are aggregated within each year and then across the previous 5 years. A block of time is used to reflect the memory associated with the disputes. We employ a rolling period, assuming that leaders and citizens are highly cognizant of the recent past. Consequently, perceptions of hostility will oe related to actions that are recognized by individuals but will fade over time. In this regard, the initial level of threat will be measured as the aggregated hostility levels for a state:

$$\text{Baseline hostility} = H_{,\_5} + H_{,\_4} + H_{,\_3} + H_{,\_2} + H_{,\_1}.$$

The aggregated hostility scores are combined with characteristics of opponent states to create the final hostility index. Three qualities are emphasized: the capability of the opponent, the regional proximity of the opponent to the state, and the state's involvement in an enduring rivalry or extended dispute.

Final Hostility Level	*Baseline Hostility*	*Major Power Opponent*	*Regional Opponent*	*Enduring Rivalry*
0	0			
	0			X
2	1-4·			
3	1-4·			X
4	1-4			
5	1-4		X	
6	1-4	X	X	
7	1-4			X
8	1-4		X	X
9	1-4	X	X	X
10	5-t8•			
❙❙	5-t8•			X
12	5-18			
13	5-18		X	
14	5-18	X	X	
15	5-18			X
16	5-18		X	X
17	5-18	X	X	X
18	> t8•			
19	> t8•			X
20	> 18			
21	> 18		X	
22	> 18	X	X	
23	> 18			X
24	> 18		X	X
25	> 18	X	X	X

a. Indicates the baseline hostility without any dispute involvement in the current year.

NAVAL RIVAL DESIGNATIONS

Note: unless otherwise specified, we assume that the goal of the state was to have a number of capital ships equal to the rival(s).

Austria-Hungary
- 1902-on: Italy

France
- 1816-1850: Great Britain (France wanted a 2:3 ratio)
- 1850-1870: Great Britain (parity)
- 1888-1899: Great Britain
- 1890-1914: Germany+ Austria-Hungary+ Italy

Italy
- 1870-1878: France
- 1879-1900: Austria-Hungary

Japan
- 1902-1906: Russia (70%)
- 1907-1940: United States

Germany
1898-1914: Great Britain
1933-1940: Great Britain
Great Britain
1816-1854: Rival is next biggest navy
1860-1899: Next two biggest navies
1900-1914: Germany
1919-1922: United States
United States
1895-1898: Great Britain
1899-1915: Germany
1919-1922: Great Britain
1922-1940: Japan
1950-1986: Russia
Russia
1885-1891: (Great Britain-France)
1892-1906: Great Britain
1907-1914: Germany
1935-1940: Germany
1950-1986: United States

The following sources (listed in the references) were used to identify the rivals: Baer (1994), Bartlett (1963), Evans and Peattie (1997), Hagan (1991), Herrick (1968), Jenkins (1973), Ropp (1987), Sokol (1968), Sondhaus (1989), and Spector (1985).

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