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Deterrence and the Arms Race: The Impotence of Power

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So much has been done in the name of nuclear deterrence, so much destructive power built by ourselves and the Russians that it may seem rather late in the day, not to say absurd, to wonder whether or not mutual deterrence really occurs and ask what evidence can be adduced to prove it. Yet such a question may be essential to an understanding of international nuclear politics. The problems thus posed are difficult, however, and cannot be solved by direct means. What one needs to do is to establish empirically whether the *conditions* necessary for deterrence to be taking place are present. A brief review of the reasons why this should be so ought to, on the other hand, give us some clues as to alternate paths we would need to take in seeking our answers.

To view the problem in its proper light we must take a number of steps back. Deterrence means that the other party is frightened away from what it otherwise might wish to do by fear of retaliation by the opposing nation.[1] In nuclear deterrence the root causes of this fear are, obviously, the nuclear weapons in the hands of opponents and their threats to use them. One would certainly think that deterrence would work best not in cases where both sides have nuclear weapons, but, precisely, in situations where the nuclear power would need feel no fear of retaliation. Surprisingly enough, deterrence does not seem to work very well precisely in situations where one side to the dispute has nuclear weapons and the other does not.

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1. The notion of deterrence was introduced in its modern form by Bernard Brodie in his classic work, *The Absolute Weapon: Atomic Power and World Order* (New York: Harcourt, Brace, 1946). The very substantial literature developed since that day is available in the massive bibliography of Richard Dean Burns, *Arms Control and Disarmament* (Santa Barbara: ABC-Clio Press, 1977). Two recent overviews that deal extremely well with the problems treated here are Jerome Kahan, *Security in the Nuclear Age* (Washington: Brookings Institution, 1975) and Bernard Brodie, "The Development of Nuclear Strategy," Center for Arms Control and International Security, UCLA, Working paper no. 11, February 1978.

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Incidents of countries without retaliatory nuclear capabilities attacking countries with immense nuclear arsenals have occurred too frequently to be disregarded. We have reviewed fully all such cases elsewhere.[2] An example will help us make the point. The Russians, for example, blockaded the US and her allies out of Berlin in 1948 and forced the US to run the blockade, and this at a time when the US had absolute hegemony in nuclear weapons and the means to deliver them to Russian targets. Why did the USSR take such a chance? Again, the Chinese attacked and routed the American army in Korea in 1950 when the US had nuclear weapons and the means to deliver them, while the Chinese had no nuclear weapons and the Russians, who were China's allies and were not involved in the war directly, probably still lacked any weapons, and in any case, certainly did not have the means to deliver them to American targets. Still again, the USSR dared invade Hungary in spite of the fact that the US had promised officially to try to liberate Eastern Europe; both the USSR and the US had nuclear weapons at the time, but the latter had a decisive advantage in that she could reach Russian targets while the USSR at the time could only reach America's European allies. The list of such examples could be made much longer. It is clear that the doctrine of nuclear deterrence does not lead one to expect non-nuclear powers to defy nuclear powers again and again, and have the nuclear powers back down. Such occurrences raise serious questions about the validity of the doctrine of deterrence.

But the proponents of deterrence tend to sidestep the problem. They argue that nuclear deterrence is not *meant* to work against non-nuclear powers, and its failure in such cases simply cannot be regarded as evidence of its inoperativeness or nonexistence. For these, only cases of mutual deterrence count.

The problem then would appear to pose itself as being one of establishing whether deterrence takes place in cases where both sides have nuclear weapons. But this proves to be a complicated business. If a nuclear power on a collision course with another nuclear power stops short of confrontation, the temptation is irresistible to argue that it did so through fear of nuclear

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2. A. F. K. Organski and Jacek Kugler, *War Ledger* (Chicago: Chicago University Press, 1980), Chapter 4; A. F. K. Organski, *World Politics* (New York: Alfred Knopf, 1968) Chapter 13. See also Alexander George and Richard Smoke, *Deterrence in American Foreign Policy: Theory and Practice* (New York: Columbia University Press, 1974), especially pp. 599–600; K. J. Holsti, *International Politics*, 3rd edition (New Jersey: Prentice Hall, 1977), p. 344; and the classic early statement of this problem in Bruce Russett's, "The Calculus of Deterrence," *Journal of Conflict Resolution* 7, 2 (June 1963), pp. 97–109.

retaliation. But then how is one to explain the behavior of the opponent that stands its ground and is not deterred? Why, for example, in the Cuban Missile Crisis, was Russia frightened off the island while the United States was not deterred from pushing Russia so near the brink of nuclear war? Would the US have been deterred had the Russians held their ground?[3] It will be obvious from this example that such a situation is not easily reproduced under experimental conditions and consequently one must approach the question in another way.

Under the nuclear deterrence doctrine, fear of the nuclear arsenal of an opponent, and his credible threat to use it deters the attacker from attacking. Nuclear deterrence then is heavily dependent on the credibility the attacker assigns to the retaliatory power of the defendant. But credibility of threats and perceptions of each contestant are inescapably rooted in the realities of the nuclear capabilities of an opponent. Given the intelligence at their disposal, each of the superpowers cannot but have a realistic appreciation of what it has to fear at the hands of the other. This fear drives each country not to fall behind in its nuclear capabilities and sets off nuclear arms racing. The rationale for all this should be plain. If each country must rely on its ability to threaten the adversary with nuclear retaliation in order to guarantee

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3. On the presence of fear Nikita Khrushchev made a clear and detailed account of his torment during the Cuban Crisis:

"I remember a period of six or seven days when the danger was particularly acute. Seeking to take the heat off the situation somehow, I suggested to the other members of the government: 'Comrades, let's go to the Bolshoi theater this evening. Our own people as well as foreign eyes will notice and perhaps it will calm them down . . .' We were trying to disguise our own anxiety, which was intense." In Nikita Khrushchev, *Khrushchev Remembers*, (Boston: Little, Brown, 1970) p. 497.

A similar account is provided for the American side by Robert Kennedy:

"I think those few minutes were the time of gravest concern for the President. Was the world at the brink of a holocaust? Was it our error? A mistake? Was there something further that should have been done? Or not done? His hand went up to his face and covered his mouth. He opened and closed his fist. His face seemed drawn, his eyes pained, almost gray. We stared at each other across the table. For a few fleeting seconds, it was almost as though no one else was there and he was no longer the President." Robert Kennedy, *Thirteen Days: A Memoir of the Cuban Missile Crisis* (New York: W. W. Norton, 1969) pp. 69–70.

Finally we have direct evidence that the weaker side believed that their nuclear capability was sufficient to impose unacceptable damage on the United States; again Khrushchev speaks:

"I am emphasizing once more that we already possess so many nuclear weapons, both atomic and hydrogen, and the necessary rockets for sending these weapons to the territory of a potential aggressor, that should any madman launch an attack on our state or on other Socialist states we would be able literally to wipe the country or countries which attack us off the face of the earth." From an address to the Supreme Soviet, January 14, 1960, in Robert Art and Kenneth Waltz (eds.), *The Use of Force* (Boston: Little Brown, 1971) p. 134.

its own safety, then each member of the dyad must keep pace with the development of its adversary's nuclear arsenal. If the credibility of the deterrent lies in the fear of retaliation, a major tool available to each nuclear power to stoke the fear of its opponent to desired levels is the judicious increase of its nuclear force to cover every possible contingency.

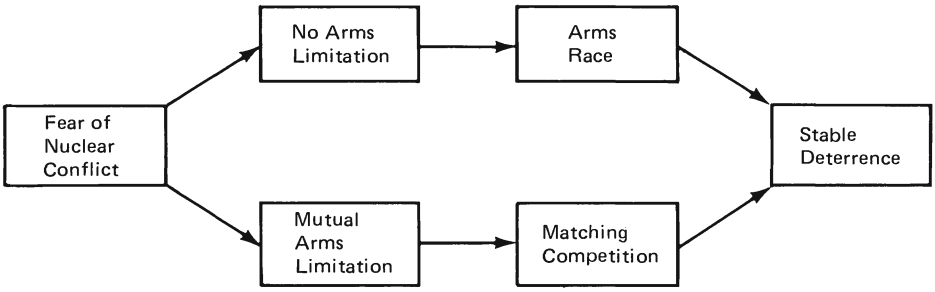
It should be noted that in the context of deterrence theory it is not necessary to assume that both sides in nuclear arms races must make the same amount of effort or have the same level of capabilities. One must assume, however, that each of the contestants will allocate substantial portions of the resources scheduled to be used in the improvement of nuclear capabilities in direct response to the other's allocations. Hence one must compete and even race with one's opponent. And the race continues even after both contestants reach a second strike capability. One must always keep in mind that the invulnerability of the defendant's deterrent depends on the power of the aggressor's initial attack. The logic of nuclear arms races, balances of terror, and deterrence are closely bound with one another.[4]

If effective arms control agreements are introduced in the model, the situation described above changes. In the absence of nuclear arms control agreements, racing is essential to keep a rough balance of nuclear capabilities, mutual fear, and, of course, mutual deterrence. With arms control agreements in being, fear is still a critical variable between the management of nuclear arsenals and deterrence, only each side is restrained from building nuclear arms beyond the limits agreed upon. Thus both sides are still competing. Though all-out racing is no longer going on, the competitors are still fearful, and they are still deterring one another.

The positions we have summarized above have long attracted scholarly attention. Over four decades ago, Lewis Richardson, in his classic *Arms and Insecurity,* stated in formal terms that increases in the allocations for arms in the budget of one side are the result of increases in the allocation for defense in the budget of its adversary. This insight was considerably extended in its

4. It should be noted that arms races are thought to be destabilizing to the international system for a very specific reason. The reason is not obvious and runs as follows: because large scale arming is very costly the economic strain of the competition where each of the competitors seek to outdo the others is very high. The weak nation is likely to tire and fall behind and is threatened with defeat if war should come. The only way out is to force a fight before it is too late, or accept the eventual ascendance of one's rival. The argument is faulty so far as nuclear weapons are concerned. We shall return to this important point in the conclusion. See Paul Smoker, "Fear in the Arms Race: A Mathematical Study," *Journal of Peace Research* 1, 1 (1964) pp. 55–64.

application to the nuclear world by introducing game theoretical logic to arms races and demonstrating very elegantly that contenders facing a "prisoner's dilemma" will act in ways that resemble arms races because they fear the consequences of cooperation.[5] Such demonstrations also indicated ways by which fear could be reduced and escalation reversed. This work is extensive but we suggest that the relevant alternatives consistent with deterrence theory can be represented as follows:



The model above contains two propositions:

1. Fear of an opponent's weapons, in the absence of any agreement to limit arms, will lead to an arms race to insure stable deterrence.
2. Fear of the nuclear capabilities of an opponent, in the presence of nuclear arms control agreements, should lead to limited arms competition and to stable deterrence.

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5. Lewis F. Richardson, *Arms and Insecurity* (Chicago: Quadrangle Books, 1960). See also Anatol Rapoport, "Lewis R. Richardson's Mathematical Theory of War," *Journal of Conflict Resolution* 1, 3 (September 1957) pp. 249–99, also his *Fights, Games and Debates* (Ann Arbor: The University of Michigan Press, 1961) Chapter 1, and Anatol Rapoport and Albert M. Chammah, *Prisoner's Dilemma* (Ann Arbor, Michigan: The University of Michigan Press, 1965). For an informal specification, see the classic presentation of Samuel Huntington, "Arms Races: Prerequisites and Results," *Public Policy* 8 (1958) pp. 41–86. For an early survey of the vast literature, see Peter Busch, "Mathematical Models of Arms Races," in Bruce Russett, *What Price Vigilance?* (New Haven: Yale University Press, 1970) pp. 193–233. For an important discussion of changes of outcomes due to variations in payoffs, see Robert Luce and Howard Raiffa, *Games and Decisions* (New York: Wiley, 1957) pp. 94–101 and for a full exploration of changes resulting from varying assumptions see Dina Zinnes, John Gillespie and Michael Rubinson, "A Reinterpretation of the Richardson Arms-Race Model," in Dina Zinnes and John Gillespie (eds.), *Mathematical Models in International Relations*, (New York: Praeger, 1976) pp. 189–216. Finally, if one assumes cybernetic, rather than rational processes, substantial changes occur, but the relationship between interaction and deterrence is not affected, see John Steinbruner, "Beyond Rational Deterrence: The Struggle for New Conceptions," *World Politics* 28, 2 (January 1976) pp. 223–45.

The causal links of the above propositions imply as follows: 1) Fear of nuclear retaliation for each of the contestants is a *necessary condition* of arms races, arms competition, arms limitation agreements, and stable deterrence to occur. 2) The expectation that nuclear weapons will deter is a *necessary condition* for nuclear nations wishing to increase or limit their nuclear arsenals. 3) In the absence of agreements to limit arms building, each side's efforts to match the arms building efforts of the other side is a *necessary condition* for stable deterrence. 4) Note also that if stable deterrence is to result under any of the conditions outlined, a direct action-reaction process must be underway between nuclear contenders. The conditions listed above are fundamental tenets of American and Russian policy. The United States and Soviet policy-makers have explicitly noted that they see a link between fear, arms races, the preservation of a balance, and stable deterrence. Alein Enthoven, a key assistant to McNamara summarized the official position of both countries:

> It is important to understand this interaction of opposing strategic forces and its relation to the strategic force planning process. If the overriding objective of our strategic nuclear forces is to deter a first strike against us, the United States must have a second-strike capability . . . This capability to destroy him even after absorbing his surprise attack must be a virtual certainty, and clearly evident to the enemy. This is the foundation of the U.S. deterrent strategy. Consequently, as long as deterrence remains the priority objective, the United States must be prepared to offset any Soviet effort to reduce the effectiveness of our assured destruction capability below the level we consider necessary.
>
> At the same time, however, if deterrence is also the Soviets' objective (as the available evidence has consistently and strongly suggested), we would expect them to react in much the same way to any effort on our part to reduce the effectiveness of their deterrent (or assured-destruction) capability against us. And we would also expect them, in their planning, to view our strategic offensive forces as a potential first-strike threat (just as we do theirs) and provide for second-strike capability. In other words, any attempt on our part to reduce damage to our society would put pressure on the Soviets to strive for an offsetting improvement in *their* assured destruction forces, and vice versa. Each step by either side, however sensible or precautionary, would elicit a precautionary response from the other side. *This "action-reaction" phenomenon is central to all strategic force planning issues as well as to any theory of an arms race.*[6]

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6. Alein Enthoven and Wayne Smith, *How Much is Enough?* (New York: Harper and Row, 1971) pp. 176–177 (italics added).

Secretary of Defense Brown recently indicated that the policy has not changed and

> . . . made it clear that the United States would prefer to maintain a nuclear balance by way of arms control agreements but that the option of taking unilateral action to preserve equivalence and stability must remain open.[7]

There is abundant evidence that US and Soviet policymakers have made the explicit link among the presence of arms races, arms control and deterrence and are acting as if these logical connections are essential for stable mutual nuclear deterrence.

Let us summarize. Mutual fear *leads* each of the contestants to build nuclear arms *in response* to the arms building programs of the other. The interactive and competitive arms building programs lead in turn to a constant rectification of the balance of terror and to stable deterrence. Were the interaction not present, the proposition underpinning the theory of nuclear deterrence would be invalid. In other words, the causal link among fear and nuclear arms races and deterrence offers the opportunity to test the validity of deterrence. The interaction between contestants is the condition essential for deterrence to occur. If an arms race can be shown to exist, and one assumes that it reflects the mutual dread consistent with the notion of deterrence, then we may also assume that deterrence is taking place. Arms competition is the obvious component of the model that lends itself most easily to empirical control and we intend to test for its presence.

There exists, however, a completely different way to explain expenditures on defense. Many have argued that to view defense budgeting with an international angle of vision (intuitively the sensible thing to do) overlooks critical portions of the reality—how in truth military budgets are put together. In fact, these observers argue, internal stimuli, rather than international factors, are year in and year out, the major factors in the allocation of resources to military power. The central proposition of this approach can be presented simply. The last allocation for defense is always the point of departure for decisions to allocate new money for arms. Organizational politics—i.e., organizational requirements, bureaucratic coalitions, factions, powerful clienteles, and independent allied decision-makers—push in the direction of increases. On the other hand, competition among bureaucracies

7. Joseph Pechman (ed.), *Setting National Priorities, the 1979 Budget* (Washington: Brookings Institution, 1978) p. 259.

for strictly finite resources tend to keep increases low. Changes in budget are, therefore, incremental. In short, budget behavior depends largely on bureaucratic and organizational competition.

Incrementalism has become a dominant theme in many areas of domestic budgeting and the models proposed by Wildavsky and his collaborators have been applied with modifications to defense policy. The work on the American process of Crecine and Kanter (using budgetary data), Tammen, Allison, Morris and Halperin analyzing how decisions are made in the development of particular weapon systems, and the less rigorous but extremely well documented analysis of the Soviet Union's procedures by Lambeth and more recently by Alexander, offers impressive testimony that the overall fluctuations of the defense budget and decisions on the development of weapon systems are made largely in response to internal pressures.[8]

We are not thinking of the problem at hand as being reducible to a clear choice between the arms race and the incremental model of budgetary expenditures. It may turn out, of course, that both internal and external pressures are responsible for decisions on defense expenditures. Most people probably hold this view and would consider the "either/or" proposition something of a red herring. The important question would really be in this view, not whether international *or* domestic variables influence the pattern of expenditures but, rather, *how much* each of the internal and external influences contribute to the total result. We, ourselves, shall follow this approach.

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8. The most general treatment is Otto Davis, M. A. H. Dempster and Aaron Wildavsky, "A Theory of the Budgetary Process," *The American Political Science Review* 60, 3 (September 1966); Aaron Wildavsky, *Budgeting, A Comparative Theory of Budgetary Processes* (Boston: Little, Brown, 1975) pp. 47–69, 344–58; see also Morton Halperin, *Bureaucratic Politics and Foreign Policy* (Washington: Brookings Institution, 1974) and Graham Allison and Morton Halperin, "Bureaucratic Politics: A Paradigm and Some Policy Implications," in R. Tanter and R. Ullman (eds.), *Theory and Policy in International Relations* (Princeton: Princeton University Press, 1972). For specific studies of defense budgeting, see John Crecine and Gregory Fisher, "On Resource Allocation Processes in the U.S. Department of Defense," Institute for Public Policy Studies Discussion Paper No. 31 (October 1971), and John Crecine, "Fiscal and Organizational Determinants of the Size and Shape of the U.S. Defense Budget," Institute for Public Policy Studies Discussion Paper No. 69 (April 1975); Arnold Kanter, "Congress and the Defense Budget: 1960–1970," *American Political Science Review* 66, 1 (March 1972) pp. 129–43; Graham Allison and Fredric Morris, "Armaments and Arms Control: Exploring the Determinants of Military Weapons," *Daedalus* 104, 3 (Summer 1975) pp. 99–189; Ron Tammen, *MIRV and the Arms Race: An Interpretation of Defense Strategy* (New York: Praeger, 1973); Benjamin S. Lambeth, "The Sources of Military Doctrine" in F. Horton, A. Roguson, and E. Warner (eds.), *Comparative Defense Policy* (Baltimore: Johns Hopkins University Press, 1974) pp. 200–215; Arthur J. Alexander, "Decision-Making in Soviet Weapons Procurement," *Adelphi Papers*, 147 & 148 (London: The International Institute for Strategic Studies 1978).

Indeed, there have been a number of disparate attempts to probe the question of whether arms races indeed exist, or whether internal pressures shape decisions on defense allocation, each of which has produced interesting suggestions but no final answers. Only a few need be mentioned here. Albert Wohlstetter, seeking to test for the presence of a nuclear arms race between the US and the USSR, examined American expenditures on nuclear weapons and found that, during the time for which the data were available, allocations went up in the first quienquennium, but came down in the second.[9] His findings however could not rule out the possibility that the curvilinearity of American expenditure is part of a cyclical movement hidden from view by the inadequate length of the available series, nor the possibility that a relation between Soviet and American expenditures would have emerged from a comparison with Russian data, had Russian data been available.

Some scholars have attempted to test simultaneously the effects that internal and external factors may have on decisions to allocate resources to the building of arms, but have fallen short of their goal due to the seeming impossibility to construct a model that, given the data, could disentangle "internal" and "external" influences from one another. Two excellent studies tried. One work by Wagner, Perkins and Taagepera used Richardson's own data to show that either an arms race model or an incremental model could account equally well for the behavior of military budgets prior to World War II.[10] Thus both models could be right, and there was no way to discriminate between them. Still another study by C. Ostrom used two series of total defense expenditures by the United States and the Soviet Union, for the period 1954–1975. He confronted the two approaches and found that the incremental and arms race models performed about as well in accounting for the observed pattern of defense spending in the two countries as a random model would have done. He rightly concluded on this basis that one could not choose between the two approaches.[11] Finally, John Lambert tested only the arms race in strategic weapons but not the alternative model, and found an action-reaction to exist that was strongest over a two year period.[12] Again,

9. Albert Wohlstetter, "Is There a Strategic Arms Race?" *Foreign Policy* 15 (Summer 1974) pp. 2–21, and "Rivals, But No 'Race'," *Foreign Policy* 16 (Fall 1974) pp. 48–81.
10. See David Wagner, Ronald Perkins and Rein Taagepera, "Complete Solution to Richardson's Arms Race Equation," *Journal of Peace Science* 1, 2 (Spring 1975) pp. 159–72.
11. Charles Ostrom, Jr., "Evaluating Alternative Foreign Policy Decision-Making Models," *Journal of Conflict Resolution* 21, 2 (June 1977) pp. 235–65.
12. John Lambert, "Towards a Dynamic Two Theater Model of the East-West Arms Race," *Journal of Peace Science* 1, 1 (Autumn 1973) pp. 1–37.

one was back at the beginning. What follows is an attempt to move the problem forward.

Indicators of Arms Competition

We have selected as our indicator of nuclear capability the portion of each country's defense budget devoted to offensive strategic nuclear systems. Strategic nuclear weapons were considered those systems designed for use in total nuclear war. The indicator of nuclear capability used in the US-USSR comparison to follow reflects only the offensive strategic force: a) the cost of delivery capacity of missiles, submarines and bombers, b) spending on development and procurement of nuclear explosives, and c) the expenditure for installation and operation of nuclear strategic systems.[13] The objective is to exclude the costs of weapons which could be used in conventional wars or in tactical nuclear confrontation. As always, there is no problem at the extremes. The ICBMs and SLBMs are strategic weapons; the tank and the cannon are conventional; the neutron bomb is tactical. But clearly there also exists a class of weapons that can be used for both strategic and non-strategic purposes—the B-52 bomber, for example. In this paper, the solution to the problem has been to include in the strategic category all weapon systems that have a strategic function regardless of any additional conventional uses.

We have also concluded that the offensive strategic capability of both nations reflects most accurately the deterrence portion of the budget. We excluded the costs of the Anti-Ballistic Missile system because their military effectiveness has always been questionable and the Anti–Ballistic Missile systems have been only thinly deployed and largely abandoned in the last decade.

We have also decided, as a measure of nuclear capability, to compare the

13. The Defense Department uses similar breakdowns starting in 1962 in the annual reports. For example, *Annual Defense Department Report* FY 1974 (Washington: USPO, 1974) Table 1, p. 118. The Central Intelligence Agency adopted a similar strategy estimating in U.S. and Soviet currencies allocation of resources for nuclear arms. See The Central Intelligence Agency Research Papers, "A Dollar Comparison of Soviet and U.S. Defense Activities, 1965–1975," SR76-10053 (February 1976) Figure 3, p. 3; (There are a number of preceding publications also having relevant estimates.) "Estimating Soviet Defense Spendings in Rubles, 1970–1975," SR76-10121U (May 1976). Many academics have also adopted similar breakdowns for purposes of arms race comparisons; see, for example, Michael Squires, "Three Models of Arms Races," in Zinnes and Gillespie, *Mathematical Models . . .*, pp. 260–1; and Albert Wohlstetter, "Rivals, But No 'Race'," p. 62.

costs of strategic weapon systems (rather than number of warheads, megatonnage or one of the many aggregated measures of nuclear weapons) because of the distinct advantages it offers in tracing an overall action-reaction process. This indicator is often used by intelligence agencies, not only because it simplifies the task of comparison (otherwise of unmanageable proportions) but also because, in all countries, costs are an important factor in determining the acquisition of nuclear arms. Indeed, top decision-makers generally have an imperfect knowledge of the technical merits of individual weapons but can effectively compare the efforts they are making with those of the opposition by using the amounts of money spent on specific weapons systems. For this reason, intelligence agencies provide summary cost figures rather than complex weapon evaluations to political decision-makers who want to compare weapon availability prior to decisions on overall weapon allocations. We chose to use constant dollar figures because they reflect consistently the amount of weapons capacity obtained over time, and are adjusted for inflation.

One should make explicit the assumption underpinning any attempt to estimate the nuclear capabilities of two competitors by looking at the budgetary allocations made by the two sides over time. The assumption is that anything done by one competitor can be matched by the other provided the latter is given a few years to make the required adjustments. Technological parity, then, is not an issue. What is required is that any increase in nuclear capacity realized on one side be matched by the other either through the development of similar technologies or by substituting for them other weapons systems with equivalent destructive power. For example, many observers argue that the United States is ahead in the accuracy, reliability of delivery vehicles, solid propellants, multiple targeting and submarine technology, yet the USSR can offset these advantages with larger nuclear payloads delivered by a larger number of strategic launchers, and accomplish this at roughly equivalent costs.[14]

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14. Most observers agree that the gap in strategic weapons has been closing. See Fred Payne, "The Strategic Nuclear Balance," *Survival* 17, 3 (May/June 1975), pp. 109-10; and the *Annual Defense Department Report*, 1978, Donald Rumsfeld, pp. 60-1. The assumption of technological equivalence is common. "As you know, we have been able to observe a number of new Soviet systems which use highly advanced technology and production techniques: the Foxbat aircraft, nuclear powered ballistic missile submarines, new types of attack submarines, new radars and missiles both for missile and for air defense, anti-ship missiles, new ASW ships equipped for helicopter operations, and smaller items such as the advanced rocket-launcher introduced effectively into Vietnam. The technology of many of these systems is comparable to the U.S.

As the reader is undoubtedly aware, estimates of expenditures for strategic weapons by either the United States or the Soviet Union are most difficult to obtain and hard to compare. Distortions in such comparisons are inevitable. The consequences of such distortions, however, can be reduced. Confining ourselves, as we do, to the component made up mostly of hardware and technology, and by using constant rather than current prices to avoid distortion produced by inflation, we are able to minimize distortions produced by differential pricing. This is an important point. The estimates for the Soviet Union are reached by the device of estimating what the USSR weapons systems would have cost if they had been produced in the US. This procedure is in large part necessary to finesse the problem produced by the shroud of deep secrecy enveloping all arms building activities in the USSR; and in part, because the economic systems and the accounting procedures of the two countries are so different it would be incredibly difficult to compare defense expenditures in any other way.[15] Moreover, the budget data reflect directly the nuclear capability we need to measure rather than what might be spent on weapons systems that were found wanting and had to be abandoned. We are aware that distortions are only mitigated however, and do not disappear.[16] It should be kept in mind, however, that: 1) it is precisely the distorted estimates of Russian allocations that the American decision-

technology. In some cases, however, our current systems are clearly more advanced." *Defense Program and Budget* FY 1971, A Statement by Secretary of Defense Melvin R. Laird before the House Subcommittee on DOD Appropriations, p. 67 (Washington: USPO, 1971). Also, see William Baugh, "An Operations Analysis Model for the Study of Nuclear Missile System Policies," in Zinnes and Gillespie, *Mathematical Models . . .* , p. 277.

15. For an excellent review of problems of comparison, see Andrew Marshall, "Estimating Soviet Defense Spending," *Survival* 18, 2 (March/April 1976), pp. 73–9; see also Alec Nove, "Soviet Defense Spending," *Survival* 13, 10 (October 1971), pp. 328–32; and Michael Boretsky and Alec Nove, "The Growth of Soviet Arms Technology—A Debate," *Survival* 14, 4 (July/August 1972), pp. 169–77; W. T. Lee, "Soviet Defense Expenditures for 1955–1975," *Tempo* mimeo, General Electric Publication, (July 31, 1975); William Colby, pp. 21–23 and Diael Graham, pp. 92–95 in Joint Economic Committee, *Allocation of Resources in the Soviet Union and China, 1975* (Washington, D.C.: U.S. Government Printing Office, 1975); and Paul Cockle, "Analysing Soviet Defense Spending: The Debate in Perspective," *Survival* 20, 5 (September/October 1978), pp. 209–219.

16. Ideally one should compare the nuclear capabilities of two countries by evaluating every individual weapon system across the whole range of nuclear weapons systems in the arsenal of each country, compare such systems with their counterparts in the opposing country, and aggregate the comparisons to determine the degree and manner in which each competitor has reacted to the development of specific weapon systems by the other. One must also be able to aggregate the results of such comparisons to detect overall reaction patterns rather than individual systems responses. One should note that the detailed comparison cannot be undertaken without the development of the necessary criteria and full access to the characteristics of each weapons system. This type of work is impossible for scholars outside of the intelligence community.

makers consider when planning US nuclear defense spending, and there is good evidence that Russian leaders do the same; and 2) what we are after is to see whether there is a consistent systematic action-reaction process going on. Therefore, minor distortions in expenditures, so long as such distortions are consistent, do not affect our work.

Comparison of Russo-American Investments In Strategic Systems

The question is whether changes in Soviet outlays for offensive strategic systems in 1951–1976 are directly related to changes in expenditures for the same period, and for similar purposes, by the United States. There are, logically, only two possible sources of pressures that can account for increases in the expenditures of the two countries for strategic weapons: pressures from outside, and pressures from within each nation. Thus we constructed a simple model seeking to probe the existence of an action-reaction process between the two countries and the presence of internal pressures within each of them.

One critical issue required solution. How long an interval could be allowed to elapse before the expenditures of each contestant should no longer be considered a response to the previous expenditure of its adversary. One could argue that such intervals should be kept short. During such an interval, the retaliatory power of the defendants, or deterrence, is compromised and a potential aggressor is tempted to strike first, finishing off at one blow its competitor. The concept of mutual deterrence is based on the need to keep an adversary from gaining such an advantage. Ideally then, in testing for the presence of competition or arms races, one should set a very short interval between action of one contestant in its arms building program and the corresponding reaction of the other. One should be justified in stipulating that whatever effort one competitor made in one year the other competitor should try to match in the next. Proponents of deterrence would certainly argue, however, that any expectation of *year by year* responses is too short an interval and may not be a fair test of the presence of competition given the time necessary for detection, evaluation, development, and the deployment of nuclear weapons. But if immediate year by year responses are not a fair test how long should the interval period be? We thought that all intervals up to a maximum of five years should be fair, and, indeed, generous.[17] It seems

17. For a partly successful example see John Lambert, "Towards A Dynamic Model," pp. 1–20.

very reasonable to argue that in the context of nuclear arms, any alleged responses taking more than half a decade after the initial move of the opponent could be taken to mean that a competition, or at least effective competition, is not taking place. Thus we provide that our analysis would scan the interactions, if any, for lags in the reaction of each contestant to the expeditures of the other for anywhere between the first and the fifth. We shall return to this point when we discuss the results we obtained.

We set down two postulates. We argued that decision-makers react in fear of the total strategic arsenal of the opponent. This postulate differs from Richardson's in that he tested simply to see whether *changes* in strategic capabilities of one country were followed by *changes* in that of the other nation. Our assumption appears more in keeping with the notion of deterrence, since the deterrent fear is generated from the possible use of *all* the adversary's stockpile, and not only from the new weapons added periodically to existing stocks.[18] We still assume, however, that the decision-makers in both countries are *aware* of the decisions taken by their counterparts and that they *can* adjust budgets up or down to match.

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18. Note that in much of the deterrence literature the *absolute* level of potential destruction is used to estimate the deterrence potential. At one time this level seems to have been arbitrarily agreed upon at least in the US strategic community: "Washington's criteria for defining assured destruction are arbitrary and conservative. Back in the mid-1960s, the Pentagon hit on roughly 25% of the Soviet population and 45% of Soviet industry as a cut-off point in targeting weapons. Beyond that point, defense planners reckoned that more than double the number of weapons would be needed to gain even marginal increases in levels of destruction." John Newhouse, *Cold Down: The Story of SALT* (New York: Holt, Rinehart and Winston, 1973) p. 18. This conclusion is supported by official sources: ". . . it is the clear and present ability to destroy the attacker as a viable 20th Century nation and an unwavering will to use these forces in retaliation to a nuclear attack upon ourselves or our allies that provides the deterrent, and not the ability partially to limit damage to ourselves. . . . the first quantitative question which presents itself is: What kind and amount of destruction must we be able to inflict upon the attacker in retaliation to ensure that he would indeed be deterred from initiating such an attack? As I have explained to the Committee in previous years, this question cannot be answered precisely . . . In the case of the Soviet Union I would judge that a capability on our part to destroy, say, one-fifth to one-fourth of her population and one-half of her industrial capacity would serve as an effective deterrent. Such a level of destruction would certainly represent intolerable punishment to any 20th Century industrial nation." Statement of Secretary of Defense Robert S. McNamara before the Senate Armed Services Committee on the Fiscal Year, 1969–1973 Defense Program and 1969 Defense Budget, January 22, 1969 (Washington: USGPO, 1968) pp. 47–50. And more recently "According to one approach, planners could simply target major cities, assume that population and industry are strongly correlated with them, and measure effectiveness as a function of the number of people killed and cities destroyed. Thus, as one example, prompt Soviet fatalities of about 30 percent and 200 cities destroyed would constitute a level of retaliation sufficient to assure deterrence." Donald Rumsfeld, *Annual Defense Dept. Report*, 1978 (Washington: USPO, 1978) p. 68. The debate currently is not about the *absolute* levels needed, but how to achieve them. Presently there are approximately 8300 warheads available to the United States and 4000 available to the USSR that can be delivered by different means.

Our second postulate deals with the effects of internal pressures on expenditures for strategic arms. Two very different types of elements may be involved. First, a number of factors have been suspected, over the years, to be accountable for increases in strategic budgets: The process of research and development that creates new weapon technology, and the fact that when new weapon technologies are developed, it is hard to resist putting them to use; the political-economic complex responsible for decisions to acquire new weapons; changes in national leadership; the annual scramble of the military services for resources, etc. One cannot be certain, however, precisely which factors really influence allocations for defense, and why their pressures work.

The second element of the internal component is depreciation. The stock of offensive strategic weapons, like any other commodity, depreciates over time and needs to be refurbished, updated or replaced to maintain efficiency and effectiveness. We will assume that this depreciation can be represented at a constant rate over time and across the two nations and that the current value of all the stock of arms is equivalent to the present expenditures plus the value of all the previous years after depreciation has been taken into account. This assumption is critical for what we are going to do, but one should be clear that it can distort reality in two ways. It fails to take into account the sharply uneven way in which technological breakthroughs render obsolete one system while hardly touching another. For example, the Minuteman has remained since the sixties, with modifications, the major missile delivery system of the nuclear force of the US. On the other hand, the technology of the fighter plane has undergone drastic revisions and no standard aircraft has emerged. Second, the depreciation of the American and Russian stocks of strategic weapons is not necessarily the same. Obviously the composition of the two strategic arsenals is different, and components differ in cost, longevity and utility. In the United States, for example, the bomber fleet has far more sophisticated aircraft, allowing pilots wider latitude of decisions, and is more expensive to run and to replace than that of the Soviet Union. The American Minuteman is more serviceable. The USSR has deployed many more types of ICBMs than the United States, but some Soviet missiles are more or less obsolete.[19] These distortions are real enough. We

19. This conclusion is supported by the difference in commitment of resources to strategic systems. The Central Intelligence Agency reports that between 1967–1977: "Within the respective intercontinental attack forces, a substantial difference in emphasis on weapons is apparent: Almost 60% of the estimated dollar costs of Soviet activities during the period were for the ICBM force, compared to only about 20% for the US. On the other hand, outlays of the US bomber force comprised about 40%, compared to a Soviet share of less than 5% (excluding the

assumed, however, that equal rates of depreciation for the arsenals of the two countries is a reasonable reflection of the overall reality, because both nations maintain such large and varied systems that the distortions of individual systems tend to cancel each other out. The main effect of this assumption is that the nation with the larger stockpile of strategic weapons is affected more drastically than its competitor.

A critical point should be made here. The first and second elements in the internal component are obviously not the same, but it is possible to estimate in our model their separate effects on strategic expenditures only if we assume that the stock of offensive weapons depreciates over time and across the two nations at a constant level.

Formal Representation of Arms Allocations

Having described the components of the theory, we can now put forward a dynamic model that seeks to account simultaneously for the influence of internal and external pressures. Consider the following general equation for offensive expenditures and stock of the Soviet Union which, of course, can be replicated exactly for the United States:

$$\textbf{(1.0)} \quad \text{USSR OFF. EXP. (t)} = \gamma_1 + \alpha_1 \text{ USSR OFF. STOCK (t} - 1) + \beta_1 \text{ US OFF. STOCK (t} - 1) + \epsilon(t)$$

Model (1.0) cannot be estimated as it stands but the reduced version can approximate all the elements we desire.[20] The first component (γ) represents the constant effects of an existing disparity in the stockpile of weapons between the United States and the Soviet Union. This element can be estimated only in conjunction with the depreciation rate ($1 - \lambda$) that is introduced when we transform the equation into a statistically tractable form.[21] The second component (α) monitors the impact of the Soviet's own stock of arms on the Soviet new allocations. From our reduced equation we obtain a model

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Backfire aircraft). While the Soviets exceeded the US levels of activities for ICBMs in every year of the period and for submarines in all but two, US outlays for bombers were higher every year." Central Intelligence Agency, "A Dollar Cost Comparison of Soviet and US Defense Activities, 1967–1977," SR78-10002m (January 1978) p. 6, and Figure 3, p. 9.

20. For details, see Appendix, A4.0 and A4.1.

21. Given that depreciation is assumed to be constant across the two nations, the ratios and the absolute difference between the estimated constant coefficients can be obtained from the two equations for the Soviet Union and the United States. See Appendix A4.0 and A4.1.

that combines the effects of depreciation and the pressures from the internal political coalition, $(\alpha + \lambda)$. Thus even though we cannot estimate the internal pressures alone, we can approximate the combined effects of depreciation and politics. Moreover, making slightly different assumptions at the outset, and estimating an equation that is similar to the one Richardson[22] suggested which considers only the external components, we obtain an estimation of depreciation for this parameter.[23] The difference is theoretical since the identifiable coefficients are the same (α), but it is important because under most conditions we can empirically test which model specifies correctly the process of weapons allocation.

Finally, the third component (β) that represents the influence of the United States stock of arms on the allocations for arms by the Soviet Union can be estimated directly and not confounded by other factors. Thus, we have a clear estimate of any direct interaction between the two powers on strategic weapons.[24]

A comment is in order, since the United States' decisions on strategic expenditures are announced in July, while the Soviet Union makes all such decisions in January, the expectation is that the Soviet Union, in allocating resources to its strategic force, would respond to the previous year's decisions made in the Soviet Union. The two equations have, therefore, a slightly

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22. For those readers familiar with the Richardson model and more interested in an approach that deals with external pressures alone we removed the first component of model (1.0) and constructed the following equation:

(2.0) USSR OFF. EXP. (t) = γ_1 + β_1 US OFF. STOCK (t − 1) + ϵ (t).

This model includes depreciation, but Richardson's results can be obtained from this stock model by simply assuming that γ_1 is a trend parameter and that the depreciation rate is unity. For derivations see Appendix, A2.0 − A3.1.

23. This difference between the internal estimates (α^*) for the United States and the Soviet Union measures the difference in the level of internal pressures in the two countries: i.e., $\delta\alpha = (\alpha_1 + \lambda) - (\alpha_2 + \lambda)$. If this difference turns out to be substantial, one would be persuaded that model 1.0, which specifies internal pressures α, is correct. If the two estimates are identical one can choose between two equally plausible explanations of models 1.0 and 2.0. One can argue that depreciation is the only internal force generating pressures for investment in strategic goods. Or one can still prefer model 1.0 as theoretically more appealing, and argue that internal pressures (α) other than depreciation are identical for both nations and that the contribution for both factors are absorbed by the depreciation rate (λ). See Appendix.

24. For statistical problems associated with this estimation see John Ferejohn, "On The Effects Of Aid To Nations In An Arms Race" in Dina Zinnes and John Gillespie, ed., *Mathematical Models in International Relations*, pp. 218-224; Philip Schrod, "Statistical Problems Associated With The Richardson Arms Race Model," *Journal of Peace Research*, 3, 2, Fall 1978, pp. 159-172. Also see Appendix.

different time frame to compensate for the half year difference in budgetary periods.

RESULTS

Let us now turn to what we have found. We estimated first the strategic expenditures for all the years of nuclear competition between the United States and the Soviet Union; because the first successful explosion of a nuclear device by the USSR occurred in 1950, we started our analysis in 1952. Without altering the model we re-estimated the equation excluding the period of 1952–1954. Results are displayed in Table 1 below and Table 2 in the Appendix.[25]

The most dramatic finding is obviously the fact that the expected competitive interaction between the two countries does not materialize. It is only when the restricted sample is used that Soviet strategic expenditures account for a small portion of the American weapons allocation, but, the impact of the external component is always *negative.* In effect, one country actually reduces its expenditures for strategic weapons when the other nation increases them. And this is precisely the inverse behavior one would expect if

Table 1.
Effects of External & "Internal" Pressures on US and USSR Strategic Budgets: 1952–1976

US OFF. EXP. (t) = 7.095 + .639 US OFF. EXP. (t − 1) − .345 USSR OFF. EXP. (t)				
std. error	(3.55)	(.165)		(.196)
signific.	(.058)	(.001)		(.094)
R^2 = .72	STD. ERROR = 2.82		SIGNIFICANCE = .000	n = 25
USSR OFF. EXP. (t) = 1.835 + .933 USSR OFF. EXP. (t − 1) − .057 US OFF. EXP. (t − 1)				
std. error	(1.242)	(.071)		(.059)
signific.	(0.154)	(.000)		(.347)
R^2 = .95	STD. ERROR = 1.03		SIGNIFICANCE = .000	n = 25

25. The strategic nuclear offensive series used in this study was constructed from data provided to the Joint Economic Committee, Subcommittee on the Priorities and Economy in Government, the United States Senate. Data was taken directly from declassified 1964, 1969, and 1978 intelligence documents currently retained in the Committee files that string together Defense Department and Intelligence reports from 1945 to 1977. In the case of the USSR we found no change in the coefficients due to the exclusion of selected years. For the United States, on the other hand, the coefficients were found to be more stable, had smaller standard errors, and yielded a stronger overall fit. See Appendix, Additional Empirical Results, Table A2. Both models were stable, and no significant autocorrelation of residuals appeared in either version. See Appendix, Stability and Analysis of Residuals.

the two countries were competing. Because the internal component accounts for a large portion of the changes in strategic weapons allocations, we must conclude that internal factors determine expenditures on nuclear weapons. We conclude also, therefore, that no arms races are being waged, that the two nations are scarcely competing.

It is very important to note that the results are strongest when the interval between action and reaction is shortest, that is when we look whether allocation of American resources one year are affected by the Russian allocation in the preceding year, and vice versa. In short, one year lags produced our best fits. As we indicated we would, we tested for delayed reactions of two through five years and all such results were even less impressive than the one we reported. The argument that the US and the USSR *are* competing but the pattern of action and reaction occurs at a slower tempo than our model can detect is not correct.

We should warn the reader that it is possible that we cannot detect interaction between the two nations because the data are available for too short a period, or that the US, secure in an early strong advantage, has waited to compete until this advantage, allegedly, has been erased. This is possible. But if America and Russia were bitter enemies during this period why did the US not try to keep the nuclear advantage it had? Why would racing start at the point when levels of nuclear destructive power had passed the point of overkill many times? Such questions cannot be answered with the data we have.

Our second most important finding is that strategic offensive expenditures are strongly related to each country's own stock of weapons. Note that in the larger sample the internal component, (that is, depreciation, and the political-economic coalition pressing for increases in the allocation to the strategic arms), accounts for 95 percent of changes in strategic expenditures in the case of the Soviet Union and 72 percent for the United States despite the disturbance produced by a few unusual fluctuations of the data. In the restricted sample the 1955–1976 portion explained for the Soviet Union remains virtually unchanged but increases to 91 percent for the United States. Recall that we shortened the period of analysis for purely statistical reasons, and we do not want to overemphasize the results, but the reader should note that if one makes the adjustment, internal pressures explain almost all of the variation in strategic expenditures.

Internal factors then are the overwhelming source of pressures shaping decisions on strategic budget. It is most important to pin down, as much as

possible, the strength of the two elements making up the internal component.

The internal factors are composed of the influences of internal coalitions in control of decisions on investments in strategic goods, and the depreciation rate (λ). If we assume that depreciation is constant, the difference between the level of internal pressures in the US and USSR is approximately 20 percent. It is of interest that the overall internal forces are more influential in the USSR than in the US. But can we go further? Can we try to estimate the value of each of the two elements making up the internal component of our equation? If we succeed in estimating one of the two components we will know both.

Depreciation gives us our opportunity, although estimating depreciation without access to information about individual weapon systems, their maintenance, their durability, their numbers, etc., is uncertain business. Very rough and tentative estimates might be possible however. Based on the American experience with its own arsenal, one can suggest that strategic arms are completely replaced or abandoned in between fifteen and twenty years.[26] If this is true, we can now go on to evaluate the relative levels of influence in the two countries of the political-economic-bureaucratic coalitions (α). In the Soviet case, 92 percent of the strategic expenditures can be attributed to internal factors. Since our calculation of depreciation (λ: .75) accounts for 81 percent of the total variation in expenditures for strategic weapons, then the remaining 19 percent represent the strength of bureaucratic coalition. For the US, the corresponding results are startling. Depreciation in the American case is actually slightly higher than the yearly expenditure for strategic arms. This means, of course, that the political coalition seeking to increase expenditures for strategic goods is slowly losing ground. The findings are clear. The USSR spending trend is accelerating, the American trend is decelerating ever so slightly; but the US, given its initial advantage, is still ahead.

This finding too is arresting. The Russian coalition is many times more effective than its American counterpart in influencing the allocation of resources to the strategic arm. Perhaps in view of the extremely high level of bureaucratization in the Russian economic and political systems, such "better" Soviet performance should not surprise.[27] Still the difference in per-

26. See Appendix, Estimate of Depreciation.
27. See Alexander, "Decision Making in Soviet Weapons . . . ," *Op. Cit.*, pp. 24–43.

formance of the Russian and American coalition in adding strength to the strategic arsenal deserves further scrutiny.

On the evidence so far, one must reject the prevailing notion that there is an arms race or a direct competition between the two nations. However, could it be that the cyclical trend in the American data obscured interaction between the US and the Soviet Union expenditures and that our results were affected by our insistence on fitting data with cyclical characteristics onto a linear model? What would happen if we detrended and reanalyzed results?

We estimated the matching strategic expenditures using non-linear techniques and found a destruct cycle in the American data, and no such pattern in the Soviet case. This analysis, fully reported elsewhere, demonstrates the two trends to be almost independent of one another, and the slight relationship encountered is in the inverse direction than predicted.[28]

One final question remained in regard to the cycles of the American expenditures. Did the high and low points in the cycle shown coincide, precede or follow in a systematic manner the kind of international events which could serve to account for the fluctuations in American expenditures for nuclear weapons? For example, did expenditures on strategic weapons decrease when defense resources were being absorbed by conventional capabilities in conventional wars, and did they increase in relation to the danger of nuclear war? The fact is that they did not. The rise and fall in American expenditures had little to do with external events. Systematic analysis is difficult, but a few examples will help make the point. During the Korean War (1950–52) the expenditure on strategic capabilities was extremely high, but during the Vietnamese conflict (1965–74) it was very low. The rise in tensions produced by the Cuban crisis was followed by a decline in allocations, while the decline in tension following the conflict in Vietnam is followed by an increase in strategic expenditure. The international action-reaction process, if there was one, played no role.

Levels of Investment Efforts in the Strategic Force

We have now tried twice to test the central hypothesis of this paper. Both times our findings plainly indicated that the conditions essential for the existence of competition or of an arms race do not obtain. Such results are

28. A. F. K. Organski and Jacek Kugler, *War Ledger*, Chapter 4.

so unbelievable that we tried once more. The problem can be approached in still another way: One can monitor the level of effort the two countries make in securing strategic arms, and if such levels rise and fall in some systematic relation to one another, one can argue with some justice that there is evidence of interaction between the US and the USSR in the field of strategic nuclear weapons. We have tried to estimate levels of effort in three different ways: We considered expenditure on strategic systems as a percentage of the total defense expenditure, as a percentage of total product of the country, and as a fraction of the per capita product of each country.[29] The comparisons we made are summarized in Table 3.

The first two columns in the table give percentages of the total defense budget allocated for offensive strategic capability. A glance up and down these columns tells the following story: The USSR and the US pursue courses diametrically opposed to one another. The US moves from a high investment level of between 12 and 17 percent in the first three quinquennia of the period studied to roughly half that amount in the last decade. The Soviet Union, on the other hand, begins low in the first decade and then doubles the investment in the last fifteen years. The same, inverse relationship is found in all other measures of effort presented in Table 3. On the whole, it is clear that the countries move in opposite directions.

Turning to the percent offensive expenditure to GNP, we see that the US

Table 3.
US and USSR Levels of Effort in Developing Offensive Capabilities

	% Off. Exp. of Tot. Def. Exp.		% Off. Exp. of Total GNP		% Off. Exp. of GNP Per Capita	
	USA	**USSR**	**USA**	**USSR**	**USA**	**USSR**
1951–55	12.2	2.9	1.7	1.5	2.3	2.1
1956–60	17.7	6.6	1.7	2.1	2.3	2.9
1961–65	13.4	13.2	1.2	3.1	1.6	4.9
1966–70	5.9	12.4	0.5	2.6	0.6	3.6
1971–75	6.8	12.7	0.4	2.5	0.5	3.4

29. The distortions created by cross-national comparisons are magnified when we move away from direct comparison of weapon values to estimates of effort. The ratios we used are congruent with similar ones obtained from estimates using rubles rather than dollars. See Central Intelligence Agency, *Estimating Soviet Defense Spending in Rubles, 1970–1975* SR76-10121v (May 1976). The GNP data were obtained from the World Bank, *World Tables 1976* (Baltimore: Johns Hopkins University Press, 1976). Slight readjustments of constant values were required.

and the USSR began by investing the same fraction of the total GNP in offensive strategic weapons, but the first quinquennium represents the high point for the US and the low point for the Soviet Union. From then on, both nations proceed in linear fashion. In the seventies the USSR is spending 2.5 percent of total GNP on strategic weapons systems while the US is spending less than half of one percent. In view of the pattern that emerges when one matches investment in strategic weapons with total GNP, one should not be surprised to discover that the percentage of per capita GNP invested in strategic systems should move apart as well. The Americans and the Soviets began by extracting roughly the same fraction of per capita resources, the US at 2.3 percent and the Soviet Union at 2.1 percent, and ended at 0.5 and 3.4 percent respectively.

A number of interesting points are embedded in the figures in our table. First, there is no question but that the Russians are trying harder. Table 3 demonstrates unequivocally that, whether one measures effort by resources invested in strategic weapons as fraction of total GNP, or per capita GNP, the Russians are clearly spending more of the smaller amounts of resources available to them on strategic arms. We should note, however, that although the US is hardly trying at all, her effort in the 1950s, conceived as a percentage of her defense budget, equals the Russian effort in the 70s. Further, in the last decade the USSR has invested considerably below the level reached between 1961–65. Columns 1 and 2, on the other hand, give a somewhat different picture, which fits only partly with the patterns established by the data in the other portions of the table. Here we observe what the military establishment of the two countries decided to do with the resources allocated for defense. It should be kept in mind that these are percentage shares of different absolute totals. What is interesting is that the lows and the highs reached in the investments made by the two countries are very similar. One sees this more clearly if one compares the percent of the defense budget spent on strategic allocation in the US from 1951 to 1960, contained in the first two cells of column one, with similar expenditures by the USSR from 1966–1975, contained in the last two cells in column 2. Would it not be fair to state that both countries have made about the same level of effort, but that they made it at different times in the period? The Americans decided to do it at the beginning; the Russians decided to do it at the end.

There can be no doubt that the data are suggestive of subterranean processes which would only become distinctly visible if we could disaggregate the series we have. On the other hand, the data are explicit on one central

point: There is no process of interaction visible from the patterns of efforts analyzed. Because of the absence of this necessary condition there can be no direct arms race. These findings may seem incredible and fly in the face of all existing assumptions, but we have merely followed where our data led.

Conclusion

According to our data, then, the presence of a nuclear arms race, far from constituting a given of international politics, proves to be a chimera. We have tried again and again to test for the presence of arms competition or arms racing and we have failed to find anything each time. It is obvious that the US and the USSR are building nuclear arms, but are not doing so, as they allege, because they are racing or competing with one another. The absence of competition or races between the two countries leads to the startling finding that logical conditions for deterrence are absent, and by inference to the conclusion, that mutual deterrence is not taking place. This is shocking. Our finding does not fit with notions of the way the two contenders function and how they interact. Important implications arise from our conclusions. Hard questions must be asked.

But first an aside about a non-event. If nuclear arms races existed, they still would not be as dangerous to peace as conventional arms races. We have already noted why non-nuclear arms races *are* dangerous to peace. In classic arms race theory, intolerable economic strain is the mechanism whose detonating action brings war about. Racing is very costly; with each side straining to outdo the other, the economically weaker nation tries and eventually forces the fight lest it should fall too far behind. Nuclear arms, on the other hand, are not costly: in both the US and the Soviet Union, they represent a small fraction of total expenditures on defense. Consequently, neither the US nor the USSR could possibly weary (at least not in the foreseeable future) from the *economic drain* incurred in the stockpiling of *nuclear* arms. Hence increases of nuclear stockpiles cannot ignite war for the reasons given for non-nuclear arms races.

If nuclear arms races are not really taking place, why is it that leaders of the major nuclear powers insist they are? Why urge arms control? Why SALT? A number of explanations come to mind, but only one fits with the finding that, in Russian and American decisions to acquire nuclear weapons, external factors play no part. The argument runs something like this: These leaders are concerned not with external threats, but with mounting defense

costs. They seek arms-control agreements as valuable aids in their efforts to resist demands for ever greater allocations of resources to strategic forces from many quarters of the heterogeneous coalitions essential to the governing of their own nations. The way we account for the desire for arms control almost suggests that American Presidents and the Chairman of the Politburo of the Soviet Union are natural allies in league against coalitions of their own subordinates, and that such groups of subordinates may well be tacit allies against their superiors. It is a conception of the stratification of the international system not ordinarily considered. It is also a new view of the way the politics of each unit affects or tries to affect the international system.

Arms control agreements make possible by their very nature, as seen in this new light, satisfactory compromises. A SALT agreement, for example, would offer all of the contenders their second choices. The establishment of an internationally-agreed ceiling would help contain internal pressures for more resources for strategic arms. On the other hand, the coalitions in each country pushing for more investments in nuclear weapons are at least assured of an internationally-agreed level of investment in the strategic forces. Both sides would not get all they might want, but each side would get something of importance.

The reader will certainly see that this explanation does not really square with our earlier observation that nuclear weapons are relatively inexpensive, and that, therefore, preventing or limiting increases in the nuclear field does not save much money. If reducing costs is the goal of arms control, is it not better to control more costly and less efficient conventional defense programs? The question is well taken. A plausible answer would be to suggest that arms-control agreements in the nuclear field would, first of all, signal a major decrease in external danger. With that established, maximum effort for security would no longer seem to be needed; thrift becomes the rule and one could turn to paring other portions of the budget, less efficient and more costly than nuclear weapons, but also less vulnerable to cutbacks so long as an atmosphere of all-out effort in matters of security exists.

Our data also show the behavior of the USSR in its allocation of resources in the nuclear field to be almost linear, while American behavior shows up as heavily cyclical. Intuitive explanation of such differences, while tempting, is not reliable. The cycles of American behavior are not in response to changes in external threat. We therefore advance the hypothesis that the differences in the Soviet-American patterns of expenditures reflect the fact that in America, research, development and production of nuclear weapons are carried

on in the private sector with acquisition and deployment of such weapons carried on by the governmental system. In the case of the USSR, research, development and production as well as deployment of strategic arms are carried on entirely in the public sector. But clearly more work is required.

Our findings disturb the common wisdom on nuclear international politics in yet another way. If one believes that nuclear mutual deterrence is operative, the horror with which the elites and mass publics of the US have regarded the proliferation of nuclear capabilities to the USSR, then to France, then to China, and finally India (with other nations waiting in the wings) seems to be the reaction of people whose anxieties have outpaced their capacity to analyze the problem. While the possibility of accidental war increases with the spread of nuclear weapons, it is also true, if one believes the doctrine of deterrence, that the spread of nuclear weapons to many countries should also spread stable deterrence.[30] It does seem a contradiction of logic thus, to believe at one and the same time in the doctrine of nuclear deterrence, and to regard nuclear proliferation as having no benefit for peace. On the other hand, if our conclusions are correct and nuclear arsenals are built almost solely as a result of internal pressures rather than external factors, and deterrence is *not operative*, then nuclear proliferation is dangerous to peace, is rightly feared, and should be stopped.

Finally, how is one to make sense of a finding that strategic arms races and mutual deterrence are both illusions? No present answer is complete, but there is a plausible explanation. There is evidence that the various US/USSR experiences of discovering each other as bitter competitors after World War II were never properly analyzed or understood by either nation and that the resulting anger, bewilderment and suspicion have dominated the relations of the two countries from that day onward. Each country identified the other as the enemy, and this coding amounted to a license for strong, continuing strategic arms buildups. How and why these original impressions have been passed on from one generation to another, how each new set of leaders was socialized into seeing the world with their predecessors' eyes, regardless of the way it really was, is not really known. Moreover, the American side provided a rationale that turned the purpose of strategic

30. For a formal demonstration of the conditions under which nuclear proliferation insures stable deterrence rather than increases the probability of war, see Michael Intrilligator and Dagobert Brito, "Nuclear Proliferation and the Probability of War," Center for Arms Control and International Security, (UCLA 1979).

arms completely around. Strategic arms were there not to fight with but to keep the peace. Be that as it may, from the late 1940s to the present there has been no let-up in the perceived necessity to acquire strategic weapons. No analysis has been done to see whether beginning or continuing to arm is or was really appropriate to the circumstances of the time, or whether strategic arms programs were or are really matching the strategic punch on the other side. The builders of strategic arms have operated in almost totally closed systems. Perhaps the discovery that they have not been interacting would not upset them.

It seems fitting, nevertheless, to close with an evaluation by the originator of deterrence, Bernard Brodie:

> The numbers of these (strategic) forces, incidentally, grew during the nineteen sixties like the British Empire was said to have grown—in a series of fits and absentmindedness. There are reasons why the number 1,000 was chosen rather than a lesser number of Minuteman missiles, in addition to our 56 Titans, and also why we chose to build 41 Polaris-Poseidon submarines capable of firing 16 missiles each, in addition to the 400 plus B-52s we had at the time, not to mention the quick reaction alert forces we had in Europe. But whatever these reasons where, they were not in response to Soviet figures.[31]

In the absence of competition, furious nuclear arms stockpiling is not easy to evaluate. While it may not be appropriate to think of the process whereby the two countries acquire strategic weapons as "neurotic," it is the term that nevertheless comes to mind. "Neurotic," then, may have to do.

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31. Bernard Brodie, "The Development of Nuclear Strategy," p. 7.

Appendix

Models

Assuming that the stock of weapons depreciates at a ratio of $(1 - \lambda)$, the current value of a stock can be estimated for nation X as:

$$\mathbf{S_x(t) = X(t) + \lambda X(t-1) + \lambda^2 X(t-2) + \ldots}$$

where $0 < \lambda < 1$

$\mathbf{X(t)}$ = Expenditures by nation X for strategic weapons in year t.

$\mathbf{S_x(t)}$ = Stock of strategic weapons at time t.

This series can be reduced to:

$$\mathbf{S_x(t) = X(t) + \lambda S_x(t-1)}$$

Using this formulation for the stock of weapons, consider the general model that included effects of internal and external sources simultaneously:

$$\mathbf{(A1.0)} \quad \mathbf{Y(t) = \gamma + \alpha S_y(t-1) + \beta S_x(t-1) + \epsilon(t)}$$

(We reproduced this equation in its country–specific form in the text.

In this form the model cannot be estimated directly. Reducing by subtraction:

$$\mathbf{\lambda Y(t-1) = \lambda\gamma + \lambda\alpha S_y(t-2) + \lambda\beta S_x(t-2) + \lambda\epsilon(t-1)}$$

yields

$$\mathbf{(A1.1)} \quad \mathbf{Y(t) = \gamma(1-\lambda) + (\alpha + \lambda)Y(t-1) + \beta X(t-1) + \mu(t)}$$

where $\mathbf{\mu(t) = \epsilon(t) - \lambda\epsilon(t-1)}$

Note that, empirically, this model *cannot* be distinguished from the model proposed by Richardson (see footnote 22), where:

$$\mathbf{(A2.0)} \quad \mathbf{Y(t) = \gamma + \beta S_x(t-1) + \epsilon(t)}$$

which again cannot be estimated directly. Subtracting

$$\mathbf{\lambda Y(t-1) = \lambda\gamma + \lambda\beta S_x(t-2) + \lambda\epsilon(t-1)}$$

yields

$$\mathbf{(A2.1)} \quad \mathbf{Y(t) = \gamma(1-\lambda) + \lambda Y(t-1) + \beta X(t-1) + \mu(t)}$$

where $\mu(t) = \epsilon(t) - \lambda\epsilon(t-1)$

From this point, the Richardson formulation can be derived by assuming implicitly that $\lambda = 1$ and that the grievance parameter (γ) is a trend parameter:

$$\textbf{(A3.0)} \quad Y(t) = \delta + \gamma(t) + \alpha \sum_{j=1}^{t-1} Y(j) + \beta \sum_{j=1}^{t-1} X(j) + \epsilon(t)$$

Again subtracting

$$Y(t-1) = \delta + \gamma(t-1) + \alpha \sum_{j=1}^{t-2} Y(j) + \beta \sum_{j=1}^{t-2} X(j) + \epsilon(t-1)$$

yields

$$\textbf{(A3.1)} \quad Y(t) = \gamma + (1 + \alpha)Y(t-1) + \beta X(t-1) + \epsilon(t) - \epsilon(t-1)$$

which is the original Richardson equation.

The equations reduced above are very similar but not identical. Consider the final version in the country–specific form:

$$\textbf{(A4.0)} \quad \text{US OFF. EXP. (t)} = \gamma_1(1-\lambda) + \alpha_1^* \text{ US OFF. EXP. (t-1)} + \beta_1 \text{ USSR OFF. EXP. (t)} + \epsilon(t)$$

$$\textbf{(A4.1)} \quad \text{USSR OFF. EXP. (t)} = \gamma_2(1-\lambda) + \alpha_2^* \text{ USSR OFF. EXP. (t-1)} + \beta_2 \text{ US OFF. EXP. (t-1)} + \epsilon(t)$$

where for model **(A4.0)**

$$\alpha_1^* = (\alpha_1 + \lambda)$$
$$\alpha_2^* = (\alpha_2 + \lambda)$$

while for model **(A4.1)**

$$\alpha_1^* = \alpha_2^* = (\lambda).$$

The decomposed parameters are:

λ = depreciation parameter assumed constant for both nations
γ_1, γ_2 = constant effects parameter for US and USSR
α_1, α_2 = internal effects parameter for US and USSR
β_1, β_2 = external effects parameter for US and USSR.

Additional Empirical Results

An examination of the residuals for the analysis presented in Table 1, showed outliers for the United States in 1952–54 and for the USSR in 1965. Without

altering the model we re-estimated the equation excluding these observations, in the hope of obtaining more stable results. They are as follows:

Table A2.
Effects of External and Internal Pressures on US and USSR Strategic Budgets: 1955–64, 1966–76

US OFF. EXP. (t) = 7.827 + .720 US OFF. EXP. (t − 1) − .451 USSR OFF. EXP. (t)				
std. error	(2.124)	(.092)		(.125)
signific.	(0.001)	(.000)		(.002)
R^2 = .92	STD. ERROR = 1.50		SIGNIFICANCE = .000	n = 21
USSR OFF. EXP. (t) = 1.932 + .920 USSR OFF. EXP. (t − 1) − .038 US OFF. EXP. (t − 1)				
std. error	(1.289)	(.079)		(.059)
signific.	(0.151)	(.000)		(.520)
R^2 = .94	STD. ERROR = .97		SIGNIFICANCE = .000	n = 21

Stability

The stability of the action–reaction model depends upon the roots of the matrix

$$\begin{pmatrix} \alpha_1^* & \beta_1 \\ \beta_2 & \alpha_2^* \end{pmatrix}$$

lying inside the unit circle, where for model **(A1.0)**

$$\alpha_1^* = (\alpha_1 + \lambda)$$
$$\alpha_2^* = (\alpha_2 + \lambda)$$

and for model **(A2.0)**

$$\alpha_1^* = \alpha_2^* = \lambda.$$

The roots (z) are given by the solution of

$$\begin{vmatrix} \alpha_1^* - z & \beta_1 \\ \beta_2 & \alpha_2^* - z \end{vmatrix} = 0$$

or

$$(\alpha_1^* - z)(\alpha_2^* - z) - \beta_1\beta_2 = 0$$

or

$$z^2 - (\alpha_1^* + \alpha_2^*)z + \alpha_1^*\alpha_2^* - \beta_1\beta_2 = 0$$

$$z = \frac{\alpha_1^* + \alpha_2^*}{2} \pm \sqrt{\frac{(\alpha_1^* + \alpha_2^*)^2}{4} - \alpha_1^*\alpha_2^* + \beta_1\beta_2}$$

$$= \frac{\alpha_1^* + \alpha_2^*}{2} \pm \sqrt{\frac{(\alpha_1^* - \alpha_2^*)^2}{4} + \beta_1\beta_2}$$

Since both β_1 and β_2 are negative, we have real roots. For the models using data from 1951–1976, we have:

$\alpha_1^* = .63928 \qquad \beta_1 = -.34453$
$\alpha_2^* = .93337 \qquad \beta_2 = -.05697$
$z = .786325 \pm .2031 = .5832, .9894$

The estimated system is therefore stable.

For the models using data from 1955–1964, 1966–1976, we have:

$\alpha_1^* = .72017 \qquad \beta_1 = -.45131$
$\alpha_2^* = .92016 \qquad \beta_2 = -.03848$
$z = .820165 \pm .1654 = .6547, .9856$

This estimated system is also stable.

Analysis of Residuals

An examination of the residuals yields the following autocorrelations for the two models estimated:

	Sample Using 1952-76 (Table 1)		Sample Using 1955-64, 1966-76 (Table A2)	
Lag	US (N = 25)	USSR (N = 25)	US (N = 21)	USSR (N = 21)
1	.11	.27	−.38	.18
2	−.29	−.30	.30	−.29
3	−.17	−.19	−.50	−.09
4	−.01	.05	.22	.04
5	.04	−.01	−.22	−.16
Approximate 95% Acceptance Interval	±.39	±.39	±.43	±.43

The Durbin-Watson test is inappropriate since the model contains the lagged value of the dependent variable as an explanatory variable. However, a different test suggested by Durbin (see Potluri Rao and Roger L. Miller,

Applied Econometrics [Belmont, CA: Wadsworth Publishing Co., 1971] pp. 123–6) yields the following test statistics (compare with the standard normal percentiles):

Durbin's h 1.716 1.618 −1.400 .746

Only the first is (barely) significant at the .05 level. However, without the extreme values for the US for 1952–54 and 1965 (Table A2) the tests are not significant. Hence, procedures for estimating the coefficients in the presence of autocorrelated disturbances, such as Generalized Least Squares, Cochrane-Orcutt, etc., seem unnecessary.

It is important to remember that these are derived models, and that the disturbances in the derived model have a different pattern of autocorrelation than in the original model (see Potluri Rao and Roger L. Miller, *Applied Econometrics*, p. 169).

If the disturbances in the original model (ϵ_t) follow a first-order autoregressive scheme, with autocorrelations:

$$\Gamma_k(\epsilon) = \rho^k \qquad k = 1, 2, \ldots$$

and we apply the transformation yielding disturbances $\mu_t = \epsilon_t - \lambda\epsilon_{t-1}$ then the disturbances in the derived model (μ_t) have autocorrelations:

$$\Gamma_k(\mu) = \frac{(1 + \lambda^2)\rho^{|k|} - \lambda\rho^{|k-1|} - \lambda\rho^{|k+1|}}{1 - 2\lambda + \lambda^2} \qquad k = 1, 2, \ldots.$$

If λ is "close" to ρ(e.g., $\lambda = .75$ and $\rho = .90$), then the autocorrelation function for the disturbances of the derived model will be considerably "damped." For example, with $\lambda = .75$ and $\rho = .90$, the largest autocorrelation for the derived model disturbances is at lag 1 and is less than .23.

Estimate of Depreciation

The depreciation rate for strategic weapons was calculated by approximating the life of different strategic elements in the US arsenal. The table below lists the weapons system involved, the date when each system was introduced, the date when it was removed and the total number of service years:

Table A3.
Estimated Lifespan for Selected Strategic Systems 1950–1980

Weapon System	Year Introduced	Year Deactivated	Years* of Life	
Bombers				
B-47	1952	1965	13	
B-52 C/D/E/F	1956	1977	21	Avg. = 20 yrs.
B-52 G/H	1959	1980s	26	
ICBMs				
Atlas	1959	1964	5	
Titan II	1962	1980s	23	
Minuteman I	1962	1974	12	Avg. = 14.8 yrs.
Minuteman II	1966	1980s	19	
Minuteman III	1970	1980s	15	
Submarines				
George Washington	1960	1980s	25	
Ethan Allen	1962	1980s	23	Avg. = 23 yrs.
Lafayette	1964	1980s	21	
SLBMs				
Polaris A-2	1962	1975	13	
Polaris A-3	1964	1980s	21	Avg. = 16.3 yrs.
Poseidon C-3	1970	1980s	15	

* Years of Life computed to 1985 for systems still active.

The data required for such calculations was obtained from a collection prepared in 1968–73 by Janet Burmester for the Nuclear Balance Project, University of Michigan. For later years data were obtained from the United States Air Force, *Statistical Digest and Monthly Aircraft and Missile Digest,* 1946–1972, and *World Armaments and Disarmaments, SIPRI Yearbooks,* 1974–1977 (Cambridge: MIT Press). This table distorts actual depreciation somewhat because some systems are only partly deployed, while others are fully operational; adjustments for such deviations appeared infeasible, however, because of the differences in costs involved. We also assume that all active systems will depreciate completely by 1985 which may involve another distortion. Moreover, we do not consider the costs of refurbishing, updating and improving present equipment. We conclude that the life of strategic

equipment is approximately 15 to 20 years. We can now insert this value in our original depreciation formula. Recall that:

$$S_x(t) = X(t) + \lambda S_x(t - 1)$$

The complete depreciation of existing stock can be simply calculated as follows:

after 1 year: $\lambda S_x(t)$;
after 2 years: $\lambda^2 S_x(t)$;
⋮
after n years: $\lambda^n S_x(t)$.

We can calculate the depreciation rate (λ) specifying at what value (e.g., 1 percent, 5 percent, etc.) the stock will be considered totally depreciated and how many years it will take for the stock of weapons to depreciate to that point. Thus, for example, if we assume 1 percent of value as total depreciation and we assume that it will take 15 years for the stock to reach one percent of its original value we can calculate that e.g.,

$$15 = \sqrt{.01} = .736.$$

Of course, different solutions will be obtained depending on the level that is set as total depreciation and the number of years assumed to be required to reach that level. Some reasonable ranges are:

	Assumed rate of depreciation	Years	
		15	20
Value of the Stock at End of Period	.1%	.631	.708
	1%	.736	.794
	5%	.819	.861

In our analysis we use .75 which is the approximate mean between 15 and 20 years when total depreciation is considered to be reached at .01.