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RECASTING THE PROLIFERATION OPTIMISM-PESSIMISM DEBATE

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IN MOST COUNTRIES, public and media discussions of the spread of nuclear weapons take it for granted that such proliferation is dangerous and undesirable. This consensus is not shared among scholarly security specialists, who instead have long debated the likely consequences of nuclear proliferation.[1] A number of prominent realist and rational choice International Relations scholars have argued, in a position that has been labeled "proliferation optimism," that there is virtually no risk that nuclear weapons will actually be detonated if more countries obtain them. Because optimists also believe that nuclear deterrence greatly reduces the probability of major conventional war, many even advocate selective proliferation, provided it occurs gradually.[2] A 1981 Adelphi Paper by Kenneth Waltz, whose subtitle suggests "more may be better," remains the classic exposition of this position.[3]

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1. Because the literature on this debate is now quite extensive, I do not include the standard introductory footnote that cites all the studies. Instead, I refer readers to the very thorough literature review by Peter R. Lavoy, "The Strategic Consequences of Nuclear Proliferation," *Security Studies* 4, no. 4 (summer 1995): 695–753.

2. For examples involving specific countries, see John J. Mearsheimer, "The Case for a Ukrainian Nuclear Deterrent," *Foreign Affairs* 72, no. 3 (summer 1993): 50–66; and Mearsheimer's op-ed, "India Needs the Bomb," *New York Times*, 24 March 2000, A21.

3. Kenneth N. Waltz, *The Spread of Nuclear Weapons: More May Be Better*, Adelphi Paper no. 171 (London: International Institute for Strategic Studies [IISS], 1981). References below that list this title are to the Adelphi Paper and not to a later book with the same main title, coauthored with Scott Sagan (see n. 5).

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In response, other scholars have argued there are reasons to anticipate deterrence failures and accidents involving nuclear weapons, a position that has been labeled "proliferation pessimism." A 1994 article by Scott Sagan describing "the perils of proliferation" served as an important milestone in the development of the pessimist position.[4] Waltz and Sagan subsequently published a book containing modified versions of their original essays plus rebuttals to each other's arguments.[5] For this reason, the optimism-pessimism debate is also often referred to as "the Waltz-Sagan debate."

Most of the contributions to this debate have sought to inform policy, both in states that advocate nonproliferation and in states that are potential proliferators.[6] Waltz's Adelphi Paper, for example, includes a section laying out the "implications for American policy," while Sagan's "Perils" article closes with a discussion of "policy implications."[7] Because academic social science is often skeptical or openly dismissive of policy-oriented work, the scholars who have studied proliferation deserve credit for seeking to address an important policy issue. Unfortunately, as an effort to help the international community and potential proliferators make better decisions, the optimism-pessimism debate constitutes an inadequate and potentially misleading source of guidance.

Three conceptual problems reduce the value of the advice offered to policymakers. First, the debate has increasingly been framed as a contest between rival theories. Ascertaining which theory is stronger, however, does not necessarily lead directly to sound policy advice. A theory will be seen as superior if its predictions are correct more often than those of its rivals. If, however, even a few predictions are wrong, and the outcomes in those cases are major conventional wars or nuclear exchanges, it might not make sense to adopt the policy recommendation that has been associated with the theory in question. Determining which theory is stronger is still a relevant task, but great care must be exercised in moving from theory evaluation to the drawing of policy inferences.

4. Scott D. Sagan, "The Perils of Proliferation: Organization Theory, Deterrence Theory, and the Spread of Nuclear Weapons," *International Security* 18, no. 4 (spring 1994): 66–107.

5. Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate* (New York: Norton, 1995). Sagan and Waltz have updated and expanded their debate in a second edition of the book, *The Spread of Nuclear Weapons: A Debate Renewed* (New York: Norton, 2003). Unless otherwise noted, references below are to the first edition. Because this book has the same primary title as Waltz's earlier Adelphi Paper, references below to either edition of the debate book will include the chapter title, since the book's format treats these as though they are separate articles in an edited volume, and cite the book by the title and subtitle of the edition in question.

6. Scott D. Sagan especially emphasizes the goal of influencing policy debates in potential nuclear weapon states. See "Responses and Reflections," *Security Studies* 4, no. 4 (summer 1995): 808–10.

7. Waltz, *The Spread of Nuclear Weapons*, 28; Sagan, "The Perils of Proliferation," 105–7.

Second, the debate has focused on whether the stabilizing or destabilizing effects of nuclear weapons are stronger, without devoting as much consideration to what it would mean if both effects can be present to some degree. I will argue that nuclear weapons simultaneously have both stabilizing and destabilizing consequences, and this point has implications regardless of which impact is stronger. If nuclear weapons create pressures that push in opposite directions, then there is necessarily a trade-off between the possible benefits and the possible risks of a nuclear deterrent, and sound policy advice must include acknowledgement of this trade-off.

The need to weigh trade-offs also makes salient a third problem with the debate: it is too narrow. The entire literature focuses almost exclusively on the question of stability, that is, whether nuclear proliferation will encourage or discourage the use of force. This is obviously an important question, and if we could predict with certainty that all cases of nuclear proliferation would result in nuclear war, that would end the debate—no sane person would advocate a policy certain to produce such an outcome. It is only because the implications of proliferation for the likelihood of war, both nuclear and conventional, are in doubt that we have a debate. While stability is clearly one relevant criterion for deciding whether or not nuclear proliferation is advisable, it is not the only one. Especially because the question is one of weighing trade-offs, the economic, environmental, psychological, and domestic political implications of obtaining a nuclear arsenal should also be considered.

As a result of these three conceptual problems, the way the debate is presently framed makes the pessimist case appear weaker than it actually is. It is necessary to recast the debate so that it includes examination of all of the relevant risks and trade-offs. Because the non-stability-related consequences have received so little attention in the proliferation debate to date, the greatest portion of this article will address the economic, health and other costs that new nuclear weapon states should anticipate. Doing so will also shed new light on the stability question, as domestic political and economic impacts of nuclear arms programs may adversely affect the prospects for regional stability.[8] Recasting the optimism-pessimism debate to make it more comprehensive will not necessarily suggest that no state should ever seek nuclear arms; where the security threat is dire enough, the attractions of a nuclear deterrent will still exist. A broader analysis of the costs and benefits, however, will show there are more reasons for states to hesitate before trying to join the nuclear club than either optimists or pessimists have so far considered, and that continued nonproliferation efforts still make sense.

8. I thank Scott Sagan for suggesting this line of analysis.

KEY FEATURES OF THE LITERATURE

THOUGH THEY reach different conclusions, optimists and pessimists agree on the main criteria for judging whether proliferation's consequences will be negative. They focus on whether deterrence could break down, through any of three possible avenues. First, there must not be a preventive attack (conventional or nuclear) during the transition period when a state is developing its nuclear arsenal. Second, states must deploy survivable forces capable of retaliating in a second strike. This guards against two possible types of deterrence failure: second-strike forces ensure states do not need to adopt a launch-on-warning posture in which a false warning of attack might lead them to fire off their weapons, and they eliminate any incentive for the other side to launch a preemptive strike during a crisis (that is, they create crisis stability). I will argue below, however, that survivable second-strike forces might not be sufficient to prevent preemption, so that meeting this criterion does not guarantee the optimist prediction will be correct. Finally, third, there must not be accidental or unauthorized use of nuclear weapons.[9]

These three criteria for evaluating the stability of nuclear deterrence concern only potential negative consequences of proliferation. Obviously, if no states seek nuclear weapons, then none of these negative scenarios can happen. The three criteria address the question of whether these undesirable outcomes can also be avoided if nuclear proliferation does occur. Any positive case for proliferation must thus be made separately.

The initial optimist case was based on a mixture of logical argument and evidence drawn from the U.S.-Soviet cold war experience. Taking the empirical side of the debate first, optimists attached great weight to the absence of the Third World War, seeing it as a sign that nuclear deterrence had stabilized the U.S.-Soviet relationship. Nonproliferation advocates first responded by challenging the relevance of this case. They argued that important contextual factors would be different in the regions where future proliferation was most likely: shared borders, religious differences, and the fact the states in question had fought wars in the recent past would create stiffer challenges for deterrence in places like South Asia and the Middle East.[10]

Subsequent pessimist studies also reexamined the cold war record. This research uncovered a number of dangerous operational practices, accidents, and

9. Kenneth N. Waltz, "More May Be Better," chap. 1 in Sagan and Waltz, *The Spread of Nuclear Weapons: A Debate*, 20, and Scott D. Sagan, "More Will Be Worse," chap. 2 in ibid., 50.

10. Lewis A. Dunn, *Controlling the Bomb* (New Haven: Yale University Press, 1982); Karl Kaiser, "Non-proliferation and Nuclear Deterrence," *Survival* 31, no. 2 (March/April 1989): 123–36.

near misses during the cold war. Pessimists interpreted these incidents as evidence that nuclear war could have occurred, and they argued that future nuclear-armed states might not be as lucky.[11] In addition, both sides realized it would be a mistake to rely on just the U.S.-Soviet case. Thus, a number of studies have now also examined evidence from other regional relationships where one or more states pursued or acquired nuclear weapons.[12]

Short of the occurrence of perhaps several nuclear wars, however, the empirical record alone is not likely to settle the debate. Reflecting the adage that "facts do not speak for themselves," the relevant evidence and appropriate inferences from it are themselves matters of dispute. Hence, the contrasting logical arguments made by each side are really the heart of the debate. Optimists like Waltz have drawn on the structural realist paradigm to put forward a set of propositions others have labeled "rational deterrence theory" (RDT).[13] Optimists build their case on two broad assertions that are consistent with RDT. First, optimists argue that the costs of nuclear war are so enormous and so obvious that any leader of any state will strongly seek to avoid any chance of suffering such destruction[14] (though why this does not become a reason for predicting that most states will not want nuclear weapons in the first place is not clear[15]).

The dread of suffering nuclear devastation has two implications. First, states "have every incentive"[16] to meet the three criteria for stability. Because of the possible consequences if they do not, they will make sure that they have

11. Bruce G. Blair, *The Logic of Accidental Nuclear War* (Washington, D.C.: Brookings, 1993); Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton: Princeton University Press, 1993).

12. Devin T. Hagerty, *The Consequences of Nuclear Proliferation: Lessons from South Asia* (Cambridge: Belfer Center for Science and International Affairs and MIT Press, 1998); Mario E. Carranza, "An Impossible Game: Stable Nuclear Deterrence after the Indian and Pakistani Tests," *The Nonproliferation Review* 6, no. 3 (spring–summer 1999): 11–24; David J. Karl, "Does Nuclear Proliferation Really Matter? A Comparative Examination of Nuclear Rivalries in East Asia" (Ph.D. diss., University of Southern California, 1996); *Planning the Unthinkable: How New Powers Will Use Nuclear, Biological, and Chemical Weapons*, ed. Peter R. Lavoy, Scott D. Sagan, and James J. Wirtz (Ithaca: Cornell University Press, 2000).

13. This theoretical approach predates the proliferation debate. The most influential founding work was Thomas C. Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960).

14. For example, Waltz's Adelphi Paper, *The Spread of Nuclear Weapons*, contains eight separate passages that dwell on the costs that a state would suffer from any use of nuclear weapons against it. See 3, 5, 6, 12, 16, 21, 23, 30.

15. A recent study has used realist thinking to argue that desire to avoid becoming a nuclear target is one reason why a number of technically capable states have exercised nuclear restraint. T. V. Paul, *Power versus Prudence: Why Nations Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000).

16. Waltz, *The Spread of Nuclear Weapons*, 21.

second-strike forces and that their command and control arrangements are adequate to prevent accidents and unauthorized use.

The second implication of great costs is caution. Optimists argue that states will be exceedingly careful not to take actions that risk nuclear war. They will not attempt preventive attacks if there is even the remotest chance that the other side already possesses a few nuclear weapons. Moreover, states will not launch major conventional attacks against a nuclear-armed adversary. Because of the risk of escalation to the nuclear level, states will be wary of direct military clashes of any kind. This is where optimists get the positive case for proliferation. Once stable nuclear deterrence exists, optimists claim, major conventional war either becomes impossible or at minimum its likelihood is greatly reduced.

As a second broad assertion underpinning their case, optimists contend that meeting the three criteria for stability is easy. Nuclear weapons are relatively small and can easily be made mobile, meaning that survivable forces can readily be created by moving or hiding weapons.[17] Because even a single nuclear weapon can cause enormous destruction, effective deterrence will exist if just a few of them are survivable. Finally, survivability is in the eye of a potential attacker. If a state is not 100 percent certain that it knows the location of all of another side's weapons and that it can successfully destroy all of them, then any attack simply becomes too dangerous to consider. In short, in the optimist view, a little uncertainty goes a very long way.

Pessimists agree that states will not intentionally seek to fight a nuclear war. They argue, however, that there can be significant slippage between one's intentions and actual outcomes. According to pessimists, a number of intervening factors could lead to deterrence failure. Collectively, pessimists have put forward a mixture of situational, organizational, and psychological arguments for why states might decide to attack nuclear adversaries or take steps that inadvertently lead to nuclear use.[18]

THE PESSIMISTS' TURN TO THEORY

To make these arguments, proliferation pessimists began in the 1990s to draw explicitly on social science theories (leading some to label this new work "neopessimism"). Because, thankfully, there has never been a full-scale war

17. On this point, see esp. Jordan Seng, "Less is More: Command and Control Advantages of Minor Nuclear States," *Security Studies* 6, no. 4 (summer 1997): 50–92.

18. A study that makes use of all three types of argument is James G. Blight and David A. Welch, "Risking 'The Destruction of Nations': Lessons of the Cuban Missile Crisis for New and Aspiring Nuclear States," *Security Studies* 4, no. 4 (summer 1995): 802–41.

between two nuclear-armed states, there is no direct empirical evidence to confirm the worst fears of pessimists. To rebut optimism, therefore, pessimists must make a case that such past outcomes were partly fortuitous and provide compelling logical reasons to expect that future outcomes will not necessarily be as benign. The strongest source of such logical arguments is through deduction from a coherent, well-established theory.

Thus, in his 1994 article, Sagan noted with respect to previous criticisms of the optimist position, "What is missing in this literature, however, is an alternative *theory* of the consequences of nuclear proliferation…." About the same time, Peter Feaver also charged that pessimist theory was underdeveloped: "…Waltz's admonition to replace theory with theory is well-taken. Until now, much of the nuclear pessimist enterprise has consisted of criticizing Waltz's theory without advancing countertheories."[19]

Sagan, Feaver and others therefore sought to develop such an alternative. They adopted a decisionmaking approach, with particular emphasis on propositions derived from organization theory. For example, Sagan emphasizes biases believed to be common in military organizations. Because of these biases, Sagan argues, militaries will be inclined to pursue preventive war, and they will neglect measures to ensure that nuclear forces are survivable and are safe against accidental or unauthorized use.[20] Unfortunately, as scholarly attention has turned to evaluating the rival theories of optimists and pessimists, certain criteria for evaluation have come to the forefront that could lead to misleading or inappropriate policy recommendations.

Problems with Framing the Debate as a Theory Contest

Developing and testing theories are core tasks in the social sciences. Accordingly, social scientists have established criteria for judging which theories are best. When confronted with rival theories about a subject like proliferation, academics naturally turn to these familiar criteria to evaluate which of the two contending camps has the better argument. Determining which is the better theory, however, does not necessarily tell us what is the best policy; any attempt to infer policy lessons from theory tests should be done carefully. It makes no sense to test theories in the most rigorous manner possible, only to be casual in how one derives policy advice from the results of these tests.

19. Sagan, "Perils of Proliferation," 67–68 (emphasis in original); Peter D. Feaver, "Optimists, Pessimists, and Theories of Nuclear Proliferation Management," *Security Studies* 4, no. 4 (summer 1995): 767.

20. Sagan, "The Perils of Proliferation," passim.

Optimists and pessimists have increasingly sought to conform their work to standard social science procedures. Faced with two different theories on a question—in this case, whether proliferation will lead to stability—scholars tend to treat the two theories as competing alternatives. They therefore pit the two theories against each other in a superiority contest,[21] where the ultimate test is how well each theory matches empirical evidence. If one theory's predictions are generally confirmed while the other's are frequently falsified, there will be a natural inclination to favor the policy position associated with the stronger theory. This is not always justified, however. Policymakers have to be concerned with the incorrect predictions. It is little comfort to be told that a theory is far better than its rival if that theory turns out to be wrong in the individual case you care about.

Many pessimists have pointed this out when they are simply critiquing the optimist position. As Feaver notes:

> At best, rational deterrence theory can predict that nuclear deterrence should assure peace most of the time….[I]f RDT could successfully predict peace 99.5 percent of the time it would therefore miss .5 percent of the time. This would qualify for the social science hall of fame, but it would not make nuclear proliferation trivial…[g]iven the stakes involved….[22]

Even some nonpessimists acknowledge this point. Peter Lavoy, in a review of the Waltz-Sagan debate that sides with Waltz on many of the issues, nonetheless concludes on a cautionary note: "Policymakers…must worry about exceptions to the rule.…[O]ne exception would…dwarf the significance of the theory.…Even if Waltz is correct 99 percent of the time, the 1 percent of exceptional cases is what U.S. policymakers must worry about."[23] Richard Betts argues that this concern also follows from a classical realist outlook, which he takes pains to distinguish from Waltz's "neo-" or structural realist approach. Betts notes further that it is not clear what else might happen once there is even a single exception to the prediction of stability and that this is a further reason for caution. As he puts it, "the ramifications of the first breakage of the

21. In the international relations field, there has been in recent years a backlash against the tendency to design research around superiority contests between rival theories. Some scholars are now self-consciously seeking to synthesize or identify complementary relationships between theories. Most of the works discussed in this section, however, adopted the approach that was dominant in the mid-1990s, when they were written.

22. Peter D. Feaver, "Proliferation Optimism and Theories of Nuclear Operations," *Security Studies* 2, nos. 3/4 (spring/summer 1993): 162.

23. Lavoy, "The Strategic Consequences of Nuclear Proliferation," 752–73.

half-century taboo on nuclear use are too unpredictable to tempt us to run the experiment."[24]

Proliferation pessimists, however, do not make this their primary argument. Rather, they frame their studies in terms that could convince an academic audience that these studies disprove the arguments of proliferation optimism. In effect, this shifts the criteria used to judge the debate. By the norms of social science, one does not reject a theory because of a few wrong predictions; it takes a better, alternative theory. Pessimists thus do not rest their case on the point that one needs to be concerned about exceptions to RDT.[25] Instead, in an attempt to persuade their academic peers to reject proliferation optimism, the pessimists propose alternative theories that predict why nuclear deterrence will fail.

In short, both sides now describe the optimist-pessimist debate as a contest between rival theories. As Sagan puts it, "I compare the two theories' predictions…and…present the existing empirical evidence"; he adds that the "heart" of his disagreement with Waltz is "how *best* to explain and predict the behavior of states."[26] Feaver has even listed a set of competing hypotheses derived from "the theoretical core" of each camp: "rational deterrence theory" and "a theory of decision making, which claims that organizational, psychological, and strategic pathologies will *necessarily* corrupt RDT expectations." Feaver indicates that the theories must be evaluated against "the empirical record." "To the extent that future research supports or undermines these hypotheses, the optimist/pessimist [debate] can be resolved."[27]

In practice under this framing, proliferation optimists have been able to claim their position is the stronger one. Recent research has, quite appropriately, turned to the experiences of countries that pursued nuclear weapons programs subsequent to the first generation of nuclear weapon states. After examining these cases, several studies have concluded that the rational deterrence theory of optimists receives more support than the decisionmaking theory of pessimists.

24. Richard K. Betts, "Universal Deterrence or Conceptual Collapse? Liberal Pessimism and Utopian Realism," in *The Coming Crisis: Nuclear Proliferation, U.S. Interests, and World Order*, ed. Victor A. Utgoff (Cambridge: MIT Press, 2000), 65–66; see also 52.

25. Betts, ibid., is an exception.

26. Sagan, "More Will Be Worse," 50, and "Sagan Responds to Waltz," chap. 4 of Sagan and Waltz, *The Spread of Nuclear Weapons: A Debate*, 116 (emphasis added).

27. Peter D. Feaver, "Neooptimists and the Enduring Problem of Nuclear Proliferation," *Security Studies* 6, no. 4 (summer 1997): 122–23 (emphasis added).

RECENT EMPIRICAL EVALUATIONS

Two standard criteria have been invoked: how the rival theory performs in critical cases, and which theory explains more overall. Bradley Thayer stresses overall explanatory power. In a review of books by Bruce Blair, Sagan, and Feaver about the risks that were associated with cold war nuclear operations, Thayer argues that these authors' organizational theories cannot explain as much about nuclear doctrine and operations as can a systemic theory that emphasizes external threat.[28] Thayer, in a later article, directly compares optimist and pessimist claims and concludes that "Waltz's basic argument…is stronger."[29]

Because pessimists have stressed the risks of nuclear escalation in new nuclear regions, optimists have argued that cases where mutual nuclear status is first being achieved constitute critical cases for pessimism. In one study, David Karl compares two regional rivalries in which crises developed after both parties had achieved nuclear capabilities: the Soviet-Chinese and Indian-Pakistani relationships. Karl observes that the 1969 Sino-Soviet border conflict, when troops clashed several times along the Ussuri River, "should have been a relatively easy test for proliferation pessimism"; and, putting it in terms of the optimist perspective, he notes that "the [Indian] subcontinent is a 'least likely' case for peaceful proliferation outcomes."[30] Since crises between both sets of rivals were resolved without full-scale war, pessimism has "failed" under favorable circumstances while optimism has "passed" under unfavorable circumstances.

Devin Hagerty similarly describes South Asia as a critical case for pessimism (which he calls "the logic of nonproliferation"). Hagerty examines two Indo-Pakistani crises, in 1986–87 and 1990. He notes that these crises took place during the nuclear transition period in Pakistan, which is when pessimists see the greatest danger of preventive strikes. Hagerty suggests that "a case *refuting* that consensus…casts doubt on the logic of nonproliferation."[31] Overall, Hagerty concludes, "the Indo-Pakistani nuclear experience more closely matches the expectations of the logic of nuclear deterrence than the logic of nonproliferation."[32] Hagerty goes on to make perhaps the boldest statement of the optimist position, claiming "There is no more ironclad law in international

28. Bradley A. Thayer, "The Risk of Nuclear Inadvertence: A Review Essay," *Security Studies* 3, no. 3 (spring 1994): 449, 467.

29. Bradley A. Thayer, "Nuclear Weapons as a Faustian Bargain," *Security Studies* 5, no. 1 (autumn 1995): 150.

30. David J. Karl, "Proliferation Pessimism and Emerging Nuclear Powers," *International Security* 21, no. 3 (winter 1996/97): 102–3.

31. Hagerty, *The Consequences of Nuclear Proliferation*, 115–16 (emphasis added).

32. Ibid., 172.

relations theory than this: nuclear weapon states do not fight wars with one another."[33]

EXCEPTIONS AND QUALIFICATIONS TO THE NUCLEAR PEACE THESIS

This supposed law, if read literally, is not true. Hagerty seems to be defining war to mean only all-out military conflicts, as nuclear-armed states have fought each other at lower levels of violence. Sino-Soviet border clashes in 1969, after both countries had deployed nuclear arsenals, involved a series of fierce engagements. Since Hagerty's book was published, Indian and Pakistani troops fought in May–July 1999 around the town of Kargil in the disputed territory of Jammu and Kashmir. Accounts generally agree that the two sides suffered at least 1,000 fatalities, with some sources suggesting each side lost more than 1,000 soldiers.[34] If so, this would make the conflict a war according to the standard criteria used by political scientists, meaning the Kargil case falsified Hagerty's ironclad law less than one year after his book was published.

Any sweeping "nuclear peace" hypothesis also founders on the fact that non-nuclear weapon states have attacked nuclear weapon states. The Egyptian attack on Israel, triggering the 1973 Middle East War, and Argentina's invasion of the Falklands/Malvinas, leading to a war with Britain in 1982, should give some pause about the ability of nuclear deterrence to prevent all wars. Because Argentina was widely suspected of proliferation ambitions at that time, Britain could have feared that Argentina was potentially at the threshold of nuclear capability, but any uncertainty about this did not deter Britain from going to war, despite optimist claims that states will avoid such risks.

The empirical record also does not support an inference that nuclear-armed regions will always enjoy greater peace and stability than if they had remained free of nuclear weapons. South Africa was involved in several military conflicts in its region during the years of its nuclear weapons program, but has lived in peace with its neighbors since dismantling its nuclear arsenal. Similarly, relations in the southern cone have been less contentious in the years since Argentina and Brazil took steps to foreclose the nuclear weapons option.[35] This does not necessarily imply a direct causal link: in both cases the forswearing of nuclear weapons and regional conflict resolution took place in a context of

33. Ibid., 184.

34. K. Alan Kronstadt, "Nuclear Weapons and Ballistic Missile Proliferation in India and Pakistan: Issues for Congress," Congressional Research Service, Report RL30623, 31 July 2000, 5; Sumantra Bose, "Kashmir: Sources of Conflict, Dimensions of Peace," *Survival* 41, no. 3 (autumn 1999): 150.

35. I thank Stefan Brem for suggesting the relevance of these cases.

broader changes. The main point, however, is that these examples caution against any facile conclusion that nuclear-armed regions will be more stable than non-nuclear regions. Optimists often imply that nuclear deterrence has a unique ability to induce stability in situations where anarchy otherwise guarantees conflict. To the extent that there are empirical examples of regions achieving stable peace without nuclear proliferation, however, this premise is false. This means that, before accepting advice in favor of proliferation as a route to stability in a specific case, one must consider whether there is any feasible alternative approach that could provide a similar level of stability while avoiding the risks and costs that are unique to nuclear weapons.

Recent events in South Asia also suggest a logical flaw in any simplistic notion that mutual nuclear deterrence prevents all war. Besides the 1999 Kargil conflict, India and Pakistan also mobilized for war after an armed assault on India's parliament in December 2001, which Delhi blamed on Pakistani-supported militants. Though no new fighting has occurred as of this writing (in August 2002), the situation remains unsettled. These flare-ups in South Asia since the Indian and Pakistani nuclear tests of 1998 indicate the continued relevance of Glenn Snyder's "stability-instability paradox,"[36] in which the belief that nuclear deterrence prevents large-scale conventional conflict creates confidence in the safety of engaging in lower intensity conflict. In fact, awareness of the paradox has emboldened both sides. Pakistani officials repeatedly expressed a belief that their newly demonstrated nuclear capability would prevent India from fully utilizing its conventional superiority, and this made them willing to continue their support for insurgency in Kashmir until the reaction to the attack on India's parliament convinced Islamabad to promise restraint.[37] At the height of the crisis that followed this attack, Indian officials indicated that they too embraced the stability-instability paradox. Defense Minister George Fernandes and other Indian officials said they had no worries about using conventional forces to stop militant operations based in Pakistan, because they were convinced Pakistan would be afraid to escalate in response to Indian use of force. As one high-level diplomat put it, "there is a lot of strategic space between a low-intensity war waged with Pakistan and the nuclear threshold."[38]

36. Glenn H. Snyder, *Deterrence and Defense: Toward a Theory of National Security* (Princeton: Princeton University Press, 1961).

37. Samina Ahmed, "Security Dilemmas of Nuclear-Armed Pakistan," *Third World Quarterly* 21, no. 5 (October 2000): 788–89; Kronstadt, "Nuclear Weapons and Ballistic Missile Proliferation," 5.

38. For Fernandes' comments, see Celia W. Dugger, "India Defense Minister Belittles Pakistan's Latest Gestures," *New York Times*, 3 January 2002, A3; unnamed diplomat quoted in Seymour M. Hersh, "The Getaway," *New Yorker*, 28 January 2002, 40.

Nor are these the only such cases. David Karl has found the stability-instability paradox also operated in earlier crises between new nuclear adversaries.[39]

An earlier generation of writers thought the stability-instability paradox followed logically from RDT, and events in South Asia seem to bear this out. Although optimists expect nuclear deterrence to prevent any major escalation of such conflicts, they overstate the case if they suggest nuclear weapons prevent all forms of violence. In the wake of Kargil, Waltz now acknowledges this point. In the revised version of the *Debate* book, he has added several passages in which he notes that nuclear states may fight limited wars, but argues that the risk of nuclear war will still necessarily keep such wars limited.[40]

This brings us back to the original issue in the debate, which is the chance that nuclear weapons would be used. Both post-1998 crises in South Asia had nuclear dimensions: officials made oblique and even overt threats to use nuclear weapons, and the two sides reportedly placed their nuclear forces on heightened alert.[41] The implications of this for the optimism-pessimism debate are unclear, however. Did these actions help de-escalate the crises, thus supporting optimist expectations, or are they a sign that nuclear war could have occurred, thus supporting pessimist fears? Sagan and Waltz address this question in a new chapter written for the revised edition of their debate book, and not surprisingly they reach opposite conclusions. Below, I will suggest that in a sense they might both be right, because nuclear weapons produce contradictory effects.

This, however, should not obscure the fact that the optimist interpretation fits better with the positivist canons of mainstream social science. If one looks at the outcomes of interactions between nuclear-capable states, these outcomes match the predictions of optimists to a greater extent than they fulfill the negative concerns of pessimists, even in cases that involve the conditions that pessimists see as most dangerous. In particular, there has never been a deterrence failure leading to nuclear war. Since the pessimists have themselves asserted the need for an alternative theory to RDT and claimed to have a better theory, the optimists can hardly be blamed for thinking that, because they

39. Karl, "Does Nuclear Proliferation Really Matter?"

40. Waltz, "More May Be Better," in *The Spread of Nuclear Weapons: A Debate Renewed*, 37; and "For Better: Nuclear Weapons Preserve an Imperfect Peace," the Waltz portion of a new chap. 3, "Indian and Pakistani Nuclear Weapons: For Better or Worse?" in *The Spread of Nuclear Weapons: A Debate Renewed*, 115, 122.

41. Ahmed, "Security Dilemmas of Nuclear-Armed Pakistan," 789; Center for Nonproliferation Studies, Nuclear Abstracts Database, document 20614, no title, cites reports in two Indian publications suggesting nuclear forces were placed on alert during Kargil; Sagan, "For the Worse: Till Death Do Us Part," Sagan portion of new chap. 3 in *The Spread of Nuclear Weapons: A Debate Renewed*, 99–100.

come out ahead in the standard social science superiority tests, they have won the debate.

Even if RDT is the more accurate theory, however, this does not alone make it valid to conclude that nuclear proliferation would in some cases be for the best. For policy purposes, there is a world of difference between a probabilistic theory and an iron law. If the probability of nuclear war is very low but not zero—that is, if the nuclear peace hypothesis is probabilistic, not ironclad—there may simply not have been enough interactions between nuclear-armed states to produce a deterrence failure. In this case, if enough nuclear weapon states interact over a long enough period of time, it becomes likely that nuclear weapons will again be used against populated areas, as they were twice previously in 1945. To claim that the tacit acceptance or selective promotion of proliferation is the clearly superior policy recommendation, it is necessary (though not sufficient) that the chances of nuclear war must be so close to zero that the benefits expected from the greater incentives to avoid major conventional wars could not plausibly be offset by a risk of nuclear use. Otherwise, the issue becomes a trade-off in which one must decide what level of risk of nuclear destruction is tolerable in order to achieve the anticipated benefits of a reduced probability of conventional war.

REFRAMING THE STABILITY ISSUE: WHY RISK CANNOT BE ELIMINATED

FOR POLICY PURPOSES, therefore, it is not enough to evaluate which theory has the highest correlation with the empirical observations to date; evaluating risk is also important. One risk that must be addressed is whether there is a realistic possibility that RDT's predictions of stability could be wrong. For two reasons, I will argue in this section, optimists have underestimated the likelihood of nuclear war when proliferation occurs. First, the theories of optimists and pessimists are not necessarily mutually exclusive, but are instead potentially complementary. Second, one can deduce logical reasons why a country acting rationally (as social scientists use that term) might nonetheless get into a nuclear war even when the other side has survivable nuclear forces.

THEORY COMPLEMENTARITY

Turning to the first point, the effort to resolve the debate on the basis of theory testing leads studies to describe optimism and pessimism as contradictory rivals. The organizational and psychological arguments cited by pessimists need not, however, be seen as forming a complete alternative theory to the rational and systemic approaches favored by optimists. In fact, decisionmaking approaches are often invoked to explain deviations from rational behavior. From this perspective, one expects that most actors will, most of the time, behave in ways approximately consistent with an assumption of rationality. In some cases, however, certain actors will behave inconsistently with what a rational actor model would predict, sometimes with disastrous consequences. Decisionmaking pathologies provide a possible explanation in these deviant cases. Used in this manner, the inflexible organizational routines and variety of organizational and psychological biases invoked by decisionmaking theorists do not constitute a general theory. They therefore cannot be expected to explain a high percentage of observations. Rather, they complement a rational actor theory, explaining some of the cases where that theory's predictions are incorrect.

In short, existing proliferation pessimism is really a theory of why RDT could be wrong. To induce caution about promoting proliferation, pessimists do not need a theory that suggests RDT's predictions will be wrong in most of the interactions between nuclear-armed states; in practice, pessimists really emphasize why deterrence *could* fail, even if it succeeds more often than not. Thus, Feaver does not argue that deterrence will necessarily fail, only that there is no basis for concluding it will always succeed: "The evidence supports a probabilistic assessment that preventive strikes are unlikely, but does not admit of an assessment that rules them out entirely…."[42] Sagan expresses a stronger conviction that deterrence will eventually fail, claiming that "the common biases, rigid routines, and parochial interests of [new proliferators'] military organizations will lead to deterrence failures and uses of nuclear weapons despite national interests to the contrary."[43] Still, this is not a claim that deterrence will fail in every crisis or between every pair of nuclear states, only that it will fail at some point.

This debate about nuclear stability is simply not resolvable on the basis of empirical evidence at this point because it is about whether a low-probability event that has not been observed to date might nonetheless happen in the future. The effort to develop an alternative to RDT has been valuable in calling attention to the unexpected things that could go wrong, but given the absence of cases that bear out the worst predictions of pessimists, the logic of their theory alone is unlikely to change the minds of those who are persuaded by optimists' logic and evidence. What, however, if rational considerations themselves suggested a distinctly non-zero probability of nuclear war? Rather than

42. Peter D. Feaver, "Proliferation Pessimism and Emerging Nuclear Powers," in "Correspondence," *International Security* 22, no. 2 (fall 1997): 188.

43. Sagan, "The Perils of Proliferation," 102.

limit the debate to a theory competition, it is also important to consider whether optimists have correctly deduced all of the implications of rational deterrence logic. If RDT itself predicted nuclear war under certain plausible scenarios, the optimist argument for accepting gradual proliferation would be greatly weakened.

WHY RATIONAL BEHAVIOR DOES NOT PRECLUDE NUCLEAR USE

In fact, there are several reasons why states that behave according to social science definitions of rationality could still create or find themselves in situations that lead to deterrence failure or the use of nuclear weapons. First, it is impossible to minimize simultaneously the risks involved in each of the three scenarios by which deterrence might fail. As Peter Feaver has pointed out repeatedly, there are unavoidable trade-offs in designing a command and control system.[44] If one worries about the possibility of unauthorized use (the "fail deadly" scenario), one will choose a highly centralized command and control system. This increases the chances, however, that another state could achieve successful decapitation in a first strike (the "fail impotent" scenario), which might invite preemption. The alternative is to adopt a highly delegative system that reduces incentives for preemption by increasing the chances that one could retaliate in a second strike. Extensive predelegation of launch authority, however, also increases the risks that somebody will be able to fire off a nuclear weapon in the absence of an order to do so by central authorities. The risks of preemption and unauthorized launch may both be small, but they cannot both simultaneously be reduced to zero.

Similarly, incentives to avoid inviting preventive attack can ironically make other types of deterrence failure more likely. Potential adversaries will feel the most pressure to strike preemptively if they know a state is very close to the nuclear threshold but does not yet have a nuclear device. Hence, a state at this stage of development should rationally strive to maintain complete secrecy so no information about the extent of its progress comes to light. This leaves open a possibility, however, that an adversary will choose to go to war because it is ignorant of how close the state is to achieving nuclear capability. Under pressure of war, the state may accelerate completion of one or more nuclear devices. This, however, may not become known to the other side until it has already crossed the state's red lines, thereby creating the very "last resort" situation in which the state feels it has to use its nuclear weapons.

44. See Peter D. Feaver, "Command and Control in Emerging Nuclear Nations," *International Security* 17, no. 3 (winter 1992/93): 160–87, for his first application of this argument to proliferation.

There are two examples that could have raised such a possibility had the wars in question gone differently. According to Avner Cohen, Israel apparently put together two improvised deliverable weapons just prior to the 1967 war, even though both Egypt and U.S. intelligence believed Israel had not yet crossed the nuclear threshold.[45] If the Arabs had achieved greater success on the battlefield, they might have suffered nuclear retaliation from a deterrent they did not know existed. Similarly, prior to the 1991 Gulf War, the U.S. government apparently did not realize how close Iraq was to building its first nuclear weapon. While the United States and its coalition partners were getting their forces ready to go into action, Saddam ordered an all-out effort to complete a device that he intended to use against Israel if coalition forces marched on Baghdad.[46] Fortunately, Iraqi bomb-makers still needed at least a few months to complete the task, and the United States ultimately decided for other reasons not to make ousting Saddam one of its war aims.

INCENTIVES ARISING FROM THE DUALISTIC NATURE OF NUCLEAR ARMS

Two other reasons why nuclear war is possible under standard rationality assumptions involve the intrinsic nature of nuclear weapons themselves. Because nuclear weapons are so destructive, proliferation optimists expect states to behave extremely carefully. Fear of nuclear devastation, however, can cut two ways. It can make national leaders shrink away from the brink, as optimists expect. In addition, though, the danger of nuclear attack can also be provocative, triggering action intended to forestall the danger. In short, both "flight" and "fight" responses are possible. Their awesome destructive power means nuclear weapons are dualistic in their effects: they are likely both to dampen and to inflame tensions in regions where they are introduced.

Nuclear weapons can exacerbate tensions in two ways: by creating an increased perception of threat and by prompting efforts to limit damage in the event of nuclear war. On the first point, proliferation optimists write as if potential adversaries exist at a given, fixed level of hostility. This is unlikely to be the case. Rather, a state that acquires nuclear weapons is likely to be perceived as more threatening than it was before. This will be partly because of the new, more destructive capabilities at its disposal. In some cases, however, a state's pursuit of nuclear weapons may also change how other states view its intentions.

45. Avner Cohen, *Israel and the Bomb* (New York: Columbia University Press, 1998), 273–74.

46. Khidhir Hamza with Jeff Stein, *Saddam's Bombmaker* (New York: Scribner, 2000), 237.

This is especially likely because new and aspiring nuclear states are not always circumspect in their pronouncements. In March 1994, in the midst of a crisis over North Korea's suspected nuclear weapons program, the North's chief negotiator threatened his South Korean counterpart that a war could break out in which the South would be turned into "a sea of fire."[47] After the May 1998 nuclear tests in India, Prime Minister Vajpayee wrote President Clinton and explicitly cited a threat from China as a motivation for the tests. Statements by Defense Minister Fernandes shortly before and again shortly after the tests also described China as "potential threat number one" to India.[48] Other Indian officials publicly warned Pakistan to end its support for separatist insurgents in Kashmir. Home Minister Advani called on Islamabad to "realize the change in the geostrategic situation" and said that in the new circumstances even the option of "hot pursuit" would not be ruled out.[49] Such statements are bound to be provocative to the states against which they are directed. States on the receiving end of new, public nuclear threats will likely feel a need to display their toughness as a way to show they will not be intimidated. While nuclear weapons do encourage caution, they can also create pressures to demonstrate resolve, and any such demonstration carries with it some risk of escalation.

There is a second reason why, even if all behavior is "rational," nuclear weapons do not act exclusively to reduce the chances of war: policymakers must consider whether deterrence could fail. No responsible political or military leader will want to rest his or her nation's survival on the assumption deterrence will always work; such leaders will have to ask "what if deterrence fails?" Once strategic planners consider this question one major goal is likely to be to limit the damage that would result. The nuclear postures adopted by the United States and the Soviet Union during their rivalry show where this goal can lead: a state concerned about the possibility of deterrence failing may seek counterforce capabilities that could be used to destroy as much of the opponent's nuclear arsenal as possible before it can be used against the state.

Because a completely successful first strike is so hard to achieve, a rational leader will not launch one unless the chances of avoiding war start to look very

47. Mitchell Reiss, *Bridled Ambition: Why Countries Constrain Their Nuclear Capabilities* (Washington, D.C.: Woodrow Wilson Center Press, 1995), 266; John Burton, "N. Korea's 'Sea of Fire' Shakes Seoul," *Financial Times*, 22 March 1994, 6.

48. George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, and Los Angeles: University of California Press, 1999), 415, 417; T. V. Paul, "The Systemic Bases of India's Challenge to the Global Nuclear Order," *The Nonproliferation Review* 6, no. 1 (fall 1998), 11 n. 41.

49. "Roll Back Proxy War, Pakistan Told," *The Hindu*, 19 May 1998, http://www.indiaserver.com/thehindu/1998/05/19/thb01.htm. I thank Scott Sagan for bringing Advani's statements to my attention.

remote. There are circumstances, however, under which one could come to think that war is imminent or even inevitable. An opposing leader could be acting and talking in a way that suggests she or he does not understand or does not fear the consequences of nuclear war, or that she or he would rather see the enemy's country destroyed even at the risk of his or her country's survival. For example, prior to and during the 1991 Gulf War, Saddam Hussein's rhetoric made Israeli leaders express doubt that the Iraqi leader would be deterred from attacking Israel with chemical weapons by the threat that Israel could retaliate with nuclear weapons.[50] Alternatively, one might get false warning of nuclear attack that one believes is credible. Or one might have lost control of military units that are pressing an attack into the other side's homeland and be unable to convince the other side that these are renegade units, so that the other side issues explicit nuclear warnings.

In such circumstances, a leader can refrain from launching the country's weapons in the hope that the warning signs are wrong and war can still be avoided. If the leader is wrong, however, his or her country will suffer the full devastation of the other side's nuclear strike. In these circumstances, even if one cannot knock out all of the other side's weapons, the possibility of destroying some of them before launch might still look like the best option. Losing two or three cities is a terrible disaster, but it is not as bad as losing five or eight or ten cities. In sum, if deterrence failure appears sufficiently likely and imminent, ordering a counterforce first strike can make "rational" sense even if one does not anticipate completely successful preemption, merely as a way to try to limit the damage.[51] This may be especially so in new nuclear weapon states. Proliferation optimists assume most new proliferators will have only small nuclear arsenals. Against a country with say 10 to 20 nuclear weapons, a first strike that could knock out half or two-thirds might look attractive if the circumstances appear sufficiently dire.

The possible interest in damage limitation has implications for two specific arguments that arise in the optimism-pessimism debate. First, a number of

50. Gerald M. Steinberg, "Parameters of Stable Deterrence in a Proliferated Middle East: Lessons from the 1991 Gulf War," *The Nonproliferation Review* 7, no. 3 (fall–winter 2000): 43–60.

51. This argument is consistent with the conditions that could invite preemption that have been sketched out by Charles Glaser, "Why Do Strategists Disagree about the Requirements of Strategic Nuclear Deterrence?" in *Nuclear Arguments: Understanding the Strategic Nuclear Arms and Arms Control Debates*, ed. Lynn Eden and Steven E. Miller (Ithaca: Cornell University Press, 1989), 157; and Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction: What is the Threat? What Should Be Done?" *International Security* 16, no. 1 (summer 1991): 29.

pessimists have charged that Waltz is inconsistent.[52] He assumes rational behavior, suggests that small arsenals are better for stability (they allow achievement of second-strike capabilities, but don't involve expensive efforts to develop potentially destabilizing counterforce weapons), and then dismisses the massive nuclear buildups and war-fighting doctrines of the United States and Soviet Union as reflecting "decades of fuzzy thinking."[53] Pessimists generally argue that the U.S. and Soviet excesses mean that Waltz should also admit the possibility of lapses of rationality that could lead to deterrence failures.

It is possible, however, to resolve the argument by deciding there is no inconsistency. Although I personally believe that the superpowers' cold war nuclear postures did not make sense, one could make a case that their massive buildups and development of counterforce weapons and doctrines were a rational response to the situation as U.S. and Soviet leaders perceived it. Each believed there were circumstances under which the other might not be deterred and might launch a nuclear attack. Just in case conditions ever reached the point where one thought such a nightmare event was about to take place, it would be desirable to have the capability to target the other side's forces and to launch first, in the hope, however unlikely, that this would reduce the scale of the other's attack sufficiently that some of one's country might survive. The fact that U.S. and Soviet leaders and military planners spent so much time thinking about the unthinkable—and actively preparing for it—suggests that other nuclear weapon states might view it as rational to do so as well.

The key question is not whether such behavior really was or is rational. The question is whether such behavior is consistent with RDT and should therefore be expected even under optimist assumptions. If optimists want to defend the predictive power of RDT, they must consider the possibility that cold war superpower behavior was consistent with its predictions. The assumption that states want to survive should lead us to expect that new nuclear states will desire counterforce capabilities that might let them limit the damage if they believe an opponent's nuclear attack is imminent. If states put any weight on the possibility that deterrence might fail, they may pursue weapon systems and use doctrines that actually create crisis instability and an attendant risk of inadvertent deterrence failure.

The second implication of pressures to seek damage limitation is therefore that optimists are too quick to dismiss the possibility of preemption. Optimists

52. Daniel Deudney, "Dividing Realism: Structural Realism versus Security Materialism on Nuclear Security and Proliferation," *Security Studies* 2, nos. 3/4 (spring/summer 1993): 16; Sagan, "More Will Be Worse," 67; Feaver, "Optimists, Pessimists, and Theories," 755–56.

53. Kenneth N. Waltz, "Nuclear Myths and Political Realities," *American Political Science Review* 84, no. 3 (September 1990): 731. Waltz makes his argument for why new nuclear nations will not replicate the superpower pattern in "More May Be Better," 29–33.

argue that states will never attempt a first strike because they can never be certain of achieving 100 percent success, and the possibility of retaliation with even a few nuclear weapons makes preemption too great a risk.[54] As long as state leaders value the survival of their society,[55] this is certainly true for any premeditated "bolt from the blue." If one believes, however, that an attack by the other side is about to take place, then one might not require a guarantee of a perfect first strike, but merely a reasonable chance that one can destroy enough of the other side's forces to make a meaningful difference in the damage one suffers.

Waltz simply does not get this point. In the revised version of the debate book, he writes: "The initial advantage [of striking first] is insignificant if the cost of gaining it is half a dozen cities."[56] If leaders believe, however, that the choice has boiled down to losing six cities or losing twelve, they may see a first strike as a way to *save* six cities. If prospect theory—which suggests that people are especially willing to gamble to try to reduce what appear to be certain losses—is correct, the chances of such a choice are even greater than RDT would anticipate.[57]

This reveals the problem with phrasing the second requirement for deterrence stability as the existence of second-strike capabilities. Secure second-strike forces add greatly to crisis stability, but they are not sufficient to ensure that there are no deliberate decisions to launch first. In circumstances where there are growing doubts about whether nuclear deterrence will continue to hold, damage-limitation pressures could potentially lead to an intentional decision to preempt even with an expectation that the opponent will have some forces that could survive and strike second.

54. Waltz, *The Spread of Nuclear Weapons*, 16–17; Mearsheimer, "The Case for a Ukrainian Nuclear Deterrent," 62; Hagerty, *The Consequences*, 25–26, 49. In contrast, Thayer ("Nuclear Weapons as a Faustian Bargain," 162) does not argue that a leader needs a guarantee of 100 percent success; he says instead that a leader will not be confident of sufficient success significantly to limit the damage, which again means preemption will not be attempted. A leader, however, may not need a 100 percent guarantee of being able to achieve significant damage limitation, just the belief that there is some reasonable probability of limiting the damage enough to enable some of the country to survive.

55. Some have questioned whether every state leader will always value survival of his or her state above the achievement of some other messianic mission. For an argument that there are potential leaders whose value systems could make starting a nuclear war instrumentally rational, see William C. Martel, "Deterrence and Alternative Images of Nuclear Possession," in *The Absolute Weapon Revisited: Nuclear Arms and the Emerging International Order*, ed. T. V. Paul, Richard J. Harknett, and James J. Wirtz (Ann Arbor: University of Michigan Press, 1998).

56. Waltz, "For Better," in *The Spread of Nuclear Weapons: A Debate Renewed*, 121.

57. Jack Levy, "Loss Aversion, Framing, and Bargaining: The Implications of Prospect Theory for International Conflict," *International Political Science Review* 17, no. 2 (April 1996): 179–95.

In sum, nuclear weapons create pressures and incentives in more than one direction; their effects are dualistic. By inducing fear of nuclear war, the development of nuclear forces creates reasons to behave cautiously, which enhances stability. The same fear also creates concern in other states about the proliferator's intentions, pressures to seek damage-limitation capabilities, incentives to keep secret one's progress toward a nuclear deterrent, and trade-offs between efforts to prevent unwanted use and efforts to ensure retaliation in the event of attack. These incentives and trade-offs mean there are seemingly rational behaviors that could increase the chances of conflict and lead to either intentional or inadvertent nuclear use. Even with the existence of second-strike capabilities and fully rational behavior, there are logical reasons why the chance of nuclear war cannot be reduced to zero. When one adds to this the recognition that rational and decisionmaking approaches are in some ways complementary, so that nonrational factors could also lead to a small number of exceptional cases where deterrence fails, it should be regarded as far from proven that stable nuclear deterrence is easy to achieve and makes nuclear war impossible.

Of course, because there have been no cases of nuclear war, its possibility has also not been proven. Although the argument that the risk is real may dissuade some states from pursuing proliferation, it will not dissuade all. Some may be attracted to the expected benefits such as a reduced chance of conventional war, and may convince themselves that the chances of nuclear war really are quite small. If one granted this much of the optimist case, would it mean that selective nuclear proliferation is actually desirable?

The Need to Broaden the Focus Beyond Stability

Supporters of the gradual and selective spread of nuclear arms base their case on a utilitarian calculation. Mutual nuclear deterrence, they argue, greatly reduces (or even eliminates) the chances of large-scale conventional war. Balanced against this, most optimists accept that there is some irreducible risk of accidents or unauthorized use, but they claim these nuclear dangers have only a low probability of occurring and will not lead to further escalation.[58] Since the Kargil conflict, they also acknowledge that the stability-

58. On the possibility but low probability of unwanted use, see Shai Feldman, "Middle East Nuclear Stability," *Journal of International Affairs* 49, no. 1 (summer 1995): esp. 226ff.; Thayer, "The Risk of Nuclear Inadvertence," 462, 475; Hagerty, *The Consequences*, 28–30. For the argument that any initial use is unlikely to produce escalation, see Waltz, *The Spread of Nuclear Weapons*, 5, 23–24.

instability paradox may lead to greater low-level conflict, but again assert that fear of nuclear war guarantees such conflicts will not escalate. Hence, the optimist case rests on an expectation that the number of lives saved and physical destruction averted through the prevention of major war will outweigh the lives lost and destruction from possible accidental or unauthorized nuclear detonations and low-intensity conflict. As Waltz puts it, "The possibility of fighting at low levels is not a bad price to pay for the impossibility of fighting at high levels."[59]

Both this positive case for proliferation and the counterarguments, however, rest on estimates that involve considerable uncertainty. What is the actual probability that there will be major conventional wars in the absence of mutual nuclear deterrence, and how many casualties would such wars produce? Could an alternative approach to conflict resolution prevent war in the absence of nuclear proliferation, as in the example of Argentine-Brazilian relations? What is the likelihood of accidental nuclear launches or detonations and the number of casualties these would cause, as well as the loss of life to be expected from increased low-intensity conflict? No one on either side of the debate has attempted to provide firm estimates in response to any of these questions, and any effort to do so would require a lot of guesswork. Finally, is a utilitarian calculation even the right yardstick? Because those killed if nuclear weapons are used are most likely to be civilians, one might decide that ethical imperatives to avoid loss of civilian life require accepting a somewhat greater risk of soldiers being killed.

Given the uncertainties and value judgments involved, it may be impossible to reach any consensus conclusion about whether proliferation is good or bad for the goals of peace and stability. There are both potential benefits and potential dangers, but reasonable people may disagree about which is greater. If the arguments on one or the other side of this question do not strike a policymaker as decisive, then their decisions about proliferation might be affected by the consideration of other possible impacts of nuclear weapons programs.

Efforts to develop and deploy nuclear weapons have many consequences besides their effect on stability, some of which can seriously affect the well-being of a country's people and institutions. For more than a decade, the field of security studies has been embroiled in a debate about whether such factors should be included in the definition of security.[60] The optimism-pessimism debate, however, has paid almost no attention to this larger debate in the security field.

59. Waltz, "For Better," in *A Debate Renewed*, 122.

60. For a key early statement, see Jessica Tuchman Matthews, "Redefining Security," *Foreign Affairs* 68, no. 2 (spring 1989): 162–77.

In fact, the debate has focused almost exclusively on the stability of nuclear relationships and closely related concerns. Peter Feaver has even defined the debate in terms that suggest it is only about stability: "The optimist-pessimist debate concerns whether the spread of nuclear weapons leads to greater geopolitical stability because nuclear weapons are conducive to mutual deterrence (optimism) or whether the spread of nuclear weapons leads to greater instability because the new nuclear arsenals might be more prone to accidental, unauthorized, or even intentional use than were the superpower arsenals (pessimism)."[61] In the most comprehensive review of the debate to date, Peter Lavoy lists twelve "specific concerns about nuclear proliferation" that have been subjects of the debate.[62] All twelve involve highly traditional security concerns: the first eleven comprise different scenarios in which nuclear weapons might go off or nuclear states might initiate or experience military conflict, and the twelfth concern is a possible loss of major power influence over other states.[63] Lavoy also brings up possible economic costs, as does Steve Miller, but beyond these brief exceptions the participants in the debate have limited their discussion solely to the effects of proliferation on traditional international security concerns.[64]

There have been a couple of suggestions to broaden the debate. These have raised important considerations, but their concerns still fit within a narrow definition of security. Brad Roberts has made a compelling case for the need to consider other types of proliferation besides nuclear and to investigate how all these forms of proliferation affect the prospects for world order after the cold war.[65] Also, Nathan Busch has made an insightful argument that the pessimist

61. Peter D. Feaver, "The Theory-Policy Debate in Political Science and Nuclear Proliferation," *National Security Studies Quarterly* 5, no. 3 (summer 1999): 74. For reasons described above, I disagree with this framing of the question even if one does limit the focus to stability. It is not necessary to prove that proliferation "leads to greater instability" to argue that nuclear acquisition would be an inadvisable policy for a currently non-nuclear power. It is more relevant to consider whether the risks of nuclear war, while possibly low, are not low enough to make it worth taking the risk.

62. Lavoy, "The Strategic Consequences," 718, table 4.

63. On this specific concern viz. the United States, see also Feaver, "Optimists, Pessimists, and Theories," 771; and Steven R. David, "Risky Business: Let Us Not Take a Chance on Proliferation," *Security Studies* 4, no. 4 (summer 1995): 775–76.

64. Lavoy, "The Strategic Consequences," 735–37; Steven E. Miller, "The Case against a Ukrainian Nuclear Deterrent," *Foreign Affairs* 72, no. 3 (summer 1993): 77. In a more recent article on India and Pakistan specifically, Lavoy examines economic costs in greater detail and also begins to get into some other areas, such as domestic political consequences of proliferation (Peter R. Lavoy, "The Costs of Nuclear Weapons in South Asia," in *Nuclear India in the Twenty-First Century*, ed. D. R. SarDesai and Raju G. C. Thomas [New York: Palgrave, 2002], 259–76).

65. Brad Roberts, "Rethinking the Proliferation Debate," *Security Studies* 4, no. 4 (summer 1995): 792–96; Brad Roberts, *Weapons Proliferation and World Order: After the Cold War* (The Hague: Kluwer Law International, 1996). Richard Betts has also stressed the need for prolif-

literature, with its emphasis on command and control issues, initially overlooked problems that might arise because new proliferants could lack the ability to maintain physical security of their nuclear materials.[66] Weaknesses in this area, known as materials protection, control and accounting (MPC&A), could permit the theft or diversion of bomb-making materials. These materials could fall into the hands of terrorists, who might use them to make a radiological weapon or an actual nuclear explosive device (in the revised version of the debate book, Sagan has also added the risk of nuclear terrorism as another argument against proliferation[67]). These suggested areas for a broadened focus all make sense, but they basically involve developing a more complete picture of the effects of proliferation on international stability. None of them get at other types of costs and benefits that nuclear weapons acquisition might have for new nuclear states themselves.

If, however, policymakers are uncertain about how to weigh the hoped-for benefits in terms of regional stability against the potential risks of nuclear weapons use, other considerations may tip the balance. Below, I describe the possible costs and benefits of nuclear weapons in four other areas: economic, environmental and health, psychological, and with respect to domestic political institutions. The emphasis is on intrinsic implications of nuclear weapons programs, and not on any additional costs or benefits that might result from international reactions. Thus, the section on economic effects does not consider the costs that might arise if economic sanctions are imposed on a state for going nuclear. The goal is to establish a firm baseline of the costs and benefits that any new nuclear state should expect, even in a scenario where there are no adverse international responses.

ECONOMIC CONSEQUENCES

Conventional wisdom holds this to be an area where nuclear weapons are a net benefit. Because nuclear arms are thought to provide "more bang for the buck," there has been a belief that going nuclear enables countries to save money on defense. Waltz thus argues that "new nuclear states are likely to decrease rather than to increase their military spending," and describes nuclear acquisition as "a low cost way of leveling the playing field" with a

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eration studies to pay more attention to chemical and biological weapons ("Universal Deterrence or Conceptual Collapse?").

66. Nathan Busch, "What the Proliferation Debate Has Ignored: Command and Control, MPC&A, and the Case of China" (paper presented at the 41st annual International Studies Association convention, 14–18 March 2000, Los Angeles, Calif.).

67. See Sagan, "For the Worse," 100; and "Sagan Responds to Waltz," 157–65, in *The Spread of Nuclear Weapons: A Debate Renewed.*

conventionally superior rival.[68] This belief is almost certainly a myth, however. There are two reasons to expect that nuclear programs will add a great deal to military spending. First, developing a secure and usable nuclear arsenal actually requires an enormous investment. Second, because of the limited usefulness of nuclear weapons for purposes other than deterring existential threats, nuclear-armed states are unlikely to cut back their conventional forces.

On the first point, building a nuclear arsenal involves many separate investments. A state has to mine or purchase uranium, build special facilities to convert this uranium into fissile materials, and then construct the actual bombs or warheads. Most new proliferators will be seeking to keep this activity secret, so there will be further expenses to build the bomb-making infrastructure in a way that might let it stay hidden. In addition, most countries have felt a need to test their weapons designs before introducing them into their military forces, so there may also be expenses to construct test sites and conduct test explosions. States must also pay for the scientists and engineers whose talents are needed to make all this happen.

Once bombs are built, states also need delivery systems. Four of the original five nuclear weapon states built a "triad" of delivery vehicles: aircraft, land-based ballistic missiles, and sea-based ballistic missiles placed aboard submarines. Britain, the only nuclear power not to deploy a triad, still used both aircraft and submarine-launched missiles. These advanced weapons systems are all quite expensive to purchase or develop. There are further expenses to deploy the weapons systems and safeguard them against possible attack, such as by building hardened silos.

To be able to use the weapons if necessary adds more costs. To know where to target the weapons, states need to collect intelligence on their adversaries to identify the locations of desired targets. Furthermore, states have to develop highly survivable command and control systems to ensure the continued ability to communicate with nuclear forces in the event of war. Most states have also desired to have early warning networks to provide reliable, advance notice of nuclear attack (or reassurance that a nuclear attack is not underway). Moreover, extensive troop training is required to develop a reliable cadre of launch officers and prepare the military for possible nuclear contingencies.

Because a nuclear deterrent force involves much more than just building the bomb itself, the cumulative costs can be enormous. A research project at the Brookings Institution headed by Stephen Schwartz estimated the total nuclear-weapons-related expenses incurred by the United States from 1940 to 1996, in

68. Waltz, *The Spread of Nuclear Weapons*, 21; "For Better," in *The Spread of Nuclear Weapons: A Debate Renewed*, 112.

1996 dollars, to be a staggering $5.5 trillion. This means the costs of developing and maintaining the nuclear arsenal averaged $98 billion per year in this period.[69]

Even second-tier nuclear weapon states have spent considerable sums. Britain and France, although they benefited from defense cooperation with the United States, had to spend some $3 billion to $5 billion per year to build their nuclear deterrents. Reflecting this, as of 1993, an independent estimate placed the cumulative cost of the French nuclear program at $170 billion.[70]

The startup costs for the most recent nuclear aspirants have also been significant. Independent experts generally estimate that Iraq spent $10 billion on its bomb program before the 1991 Gulf War—but Khidhir Hamza, who was the top Iraqi bomb designer before he defected, says Iraq spent $10 billion in just three years in the late 1980s, meaning that its total costs may have been much greater.[71] Peter Lavoy calculates that India and Pakistan each had to invest more than $5 billion to produce fissile materials and a small number of weapons; this estimate does not include the additional costs for delivery vehicles, command and control, and other weapons-related expenses. Recent estimates of the likely cumulative costs by Indian analysts vary considerably. One has suggested a truly minimum deterrent could be deployed for $800 million. If India seeks a robust triad, the country's experts estimate the expense as anywhere from $13 billion to as much as $170 billion over the next 30 years.[72]

For poor countries like India and Pakistan, these investments entail significant opportunity costs. Lavoy estimates that even a minimal deterrent is equivalent to one quarter of the cost sending every Indian child to school, while journalist Rammanohar Reddy claims that what India spends on its nuclear deterrent could cover the increment necessary to provide universal elementary education in that country. According to Lavoy, the price tag for

69. Stephen I. Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons since 1940* (Washington, D.C.: Brookings Institution, 1998), 3. The $5.5 trillion figure does not include anticipated future expenses to clean up environmental contamination from the nuclear weapons program. These expenses are discussed in the next section of this article.

70. Miller, "The Case against a Ukrainian Nuclear Deterrent," 77; Albert Donnay and Martin Kuster, "France," in *Nuclear Wastelands: A Global Guide to Nuclear Weapons Productions and Its Health and Environmental Effects*, ed. Arjun Makhijani, Howard Hu, and Katherine Yih (Cambridge: MIT Press, 1995), 443.

71. Joseph DiChiaro III and Edward J. Laurance, "Nuclear Weapons in a Changing World: Consequences for Development," *The Nonproliferation Review* 1, no. 2 (winter 1994): 39; Seng, "Less is More," 64–65; Hamza, *Saddam's Bombmaker*, 334.

72. Peter R. Lavoy, "The Costs of Nuclear Weapons in South Asia," 264, 266 (the latter page cites the $800 million and $13 billion Indian estimates); T. V. Rajeswar, "Costly Deterrence," *Hindustan Times*, September 6, 1999, http://www2.hindustantimes.com/nonfram/060999/detOPI1.htm. The figure of $170 billion comes from an estimate of Rs 70,000 crore to Rs 770,000 crore cited in this last article, and is based on a conversion rate of 1 rupee crore (that is, 10 million rupees) equals $222,000.

Pakistan's missiles and nuclear weapons would be enough to both feed and educate nearly all its children.[73]

Waltz asserts the South Asian states will build only a minimal deterrent and will not overspend like the United States, because "Indian and Pakistani leaders have learned from our folly."[74] Unfortunately, the evidence suggests otherwise. In practice, each of the second-generation nuclear weapon states appears interested in following the first-generation states by deploying its weapons on a triad. Israel, India and Pakistan all possess both aircraft and land-based missiles capable of delivering nuclear weapons, and each appears interested in a sea-based leg. A June 2000 report in London's *Sunday Times* even suggested that Israel has already achieved a strategic triad. The report said that Israel had test launched a nuclear-capable missile that could be fired from its three Dolphin-class submarines.[75] India is working to develop a nuclear submarine and an accompanying sea-launched missile, to be called the Sagarika, and a draft nuclear doctrine devised by a government advisory board has recommended proceeding to deploy weapons in a triad.[76] Even Pakistan has officially "assigned a nuclear role" to its Navy. Some naval officers hope to develop the ability to launch nuclear-tipped missiles from surface ships, and a naval spokesperson reportedly stated in early 2001 that Pakistan is considering trying to place nuclear missiles on three Agosta-class submarines it purchased from France.[77] In sum, even countries that say they seek only a minimum deterrent are likely to spend at least several billion dollars and probably more developing their nuclear arsenal.

These costs might be acceptable, however, if they were offset by even greater savings from reduced spending on conventional forces. In practice, this is unlikely to be the case. As noted above, nuclear-armed states face a continued and possibly increased chance of being engaged in low-intensity conflicts. In addition, most nuclear states have sought historically to maintain robust

73. Lavoy, "The Costs of Nuclear Weapons," 267; "War in South Asia: Politics, Economics, and National Identity in India and Pakistan," summary of an Asia Program meeting at the Woodrow Wilson Center, 15 May 2002, http://www.wwics.si.edu/news/digest/warsoasia.html.

74. Waltz, "For Better," in *The Spread of Nuclear Weapons: A Debate Renewed*, 109. This is another example of Waltz citing a lack of prudence by the first nuclear powers without seeing it as possible evidence that new nuclear powers might also fail to exercise the prudence his theory predits.

75. Carnegie Endowment for International Peace, *Proliferation Brief* 3, no. 18, 29 June 2000.

76. For a summary and critique of the draft doctrine, see P. R. Chari, "India's Nuclear Doctrine: Confused Ambitions," *Nonproliferation Review* 7, no. 3 (fall–winter 2000): 123–35.

77. Ayesha Siddiqa-Agha, "Nuclear Navies?" *Bulletin of the Atomic Scientists* 56, no. 5 (September/October 2000): 13–14; Zahid Hussain, "Pakistan May Put Nukes on Submarines," AP, 22 February 2001, http://www.iranite.com/articles_posts/packistan%20puts%20nukes%20on%20subs.htm.

conventional forces as a firebreak between any conventional conflict and escalation to the nuclear level. The evidence suggests that nuclear weapon states actually end up spending more on defense than they would otherwise. For example, British and French military expenditures, measured either as a percentage of GNP or per capita, have been higher than those of Germany or the NATO Europe average.[78] Jordan Seng, writing prior to the 1998 nuclear tests in South Asia, found that overall defense spending by India, Israel, and Pakistan all increased "significantly" after they developed nuclear weapons capability. India and Pakistan both boosted their defense budgets even further after the May 1998 tests. India's defense spending rose by 11 percent in the year following the tests; then, in 2000, the defense budget went up again, by an astounding 28 percent. India allotted a further 14 percent increase for 2001, before spending started to level off in 2002 when the government requested only a 4.8 percent increase.[79] Abundant evidence thus suggests that there will not be net economic savings from going down the nuclear path.[80]

ENVIRONMENTAL AND HEALTH CONSEQUENCES

The health and environmental impacts of nuclear weapons programs are substantial and almost wholly negative. This section takes a conservative approach and describes only the risks most likely to accompany nuclear weapons production by new states. Thus, certain past activities that produced significant harm to human health are not included at all in the following discussion of expected consequences of proliferation; the most important examples are atmospheric nuclear testing and uranium mining.[81] Fortunately, further

78. Bruce D. Larkin, *Nuclear Designs: Great Britain, France, and China in the Global Governance of Nuclear Arms* (New Brunswick: Transaction Publishers, 1996), 262, table 8.2; and 278, table 8.5.

79. Seng, "Less is More," 65; Lavoy, "The Costs of Nuclear Weapons," 267–68; "India's Biggest Ever Increase in Defence Spending," *Jane's Defence Weekly*, 7 March 2000, http://www.james.com; Mark Kukis, "Pakistan Downplays Indian Arms Spending," UPI, 28 February 2002, accessed via Lexis-Nexis Academic Universe.

80. This conclusion cannot be made definitive without examining the counterfactual, that is, that spending on conventional arms would have increased even more in the absence of a nuclear weapons program. This argument may be plausible in some cases, but it is not credible in the case of India. India faced no imminent, existential threat in 1999 that required a major arms buildup in response. Its huge increase in defense spending in 2000 resulted from the Kargil conflict in 1999, but this conflict erupted in large part because of the nuclear tests the year before, which both inflamed tensions and emboldened Pakistan to believe it could act more aggressively. The nuclear program thus stimulated the development of the threat that required more conventional spending.

81. Based on current U.S. standards for estimating cancer risk from radiation, it has been estimated that fallout from worldwide atmospheric testing will cause about a quarter million fatal cancers by the end of the 21st century and more than a million fatal cancers by the time the radionuclides fully decay (Institute for Energy and Environmental Research Web site,

atmospheric testing is unlikely. One also cannot assume that new atomic weapon programs will lead to new uranium mining: future proliferants either may not have uranium deposits on their territory, or those that do may have already started mining their uranium for civil purposes and not need additional mining to obtain bomb-making materials. For certain other activities, only some of their past consequences are described below, while some of their other past features are omitted. For example, some aspects of the earliest years of U.S. and Soviet plutonium-production operations are truly appalling in retrospect,[82] but for that same reason there is no reason to assume new nuclear states will imitate these practices. Hence, I do not cite them here, in keeping with the goal of focusing only on the risks that future proliferants will find it difficult to avoid.

Even setting aside these potential concerns, considerable health and environmental threats will arise from any new attempts to make nuclear weapons. This involves one further assumption: that states will not "go nuclear" by stealing existing nuclear weapons or buying them on the black market. Despite "loose nuke" worries after the breakup of the Soviet Union, there is no known case of a state obtaining a nuclear device from the territory of another state.[83] Moreover, optimist logic requires states to do more than obtain one or two bombs. Optimists assume states will deploy a survivable second-strike arsenal, and this will require tens or perhaps hundreds of devices. The unlikelihood of acquiring so many warheads illicitly, as well as desire not to be dependent on an outside supplier for one's deterrent, will impel aspiring proliferants to develop their own infrastructure for producing nuclear weapons.

Once a state decides to seek the ability to make its own bomb, it will face some health risks that arise from nuclear-weapons work even when nothing goes wrong and others that arise from potential accidents. The main groups at risk are workers at nuclear weapons facilities and residents of nearby communities. One might hope that states will learn from the experiences of earlier nuclear states how to reduce the risks, thereby making the examples of past

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http://www.ieer.org/sdafiles/vol_4/4-2/centext.html). On the consequences of uranium mining conducted for weapons programs, see Katherine Yih et al., "Uranium Mining and Milling for Military Purposes," in Makhijani, *Nuclear Wastelands*, 105–68.

82. Interested readers can find details in Makhijani et al., *Nuclear Wastelands*; Russell J. Dalton et al., *Critical Masses: Citizens, Nuclear Weapons Production, and Environmental Destruction in the United States and Russia* (Cambridge: MIT Press, 1999); and several of the other sources cited in the discussion that follows.

83. Loose nukes are still of concern because terrorists could meet their objectives with even a single stolen bomb, and even if they cannot obtain or build a complete nuclear device, they might be able to get and use nuclear materials to create a radiological "dirty bomb." Thus, my argument here should not be construed as meaning that loose nuke concerns are not serious.

problems cited below less relevant. Three factors, however, limit the extent of learning possible. First, some risks are inherent in nuclear programs and cannot be avoided. Second, current nuclear weapon states have been loath to acknowledge the environmental and health consequences of their programs. As a result, they have attempted neither to draw nor to disseminate any lessons from their experiences, which makes it harder for others to learn from those experiences. Third, future proliferants are unlikely to give priority to learning how to avoid environmental problems or to putting any lessons learned into practice.

There are three reasons why future proliferants are unlikely to minimize health and environmental risks: these are the secrecy, urgency, and larger mindset associated with nuclear weapons programs. Because nuclear arms projects are typically shrouded in secrecy, it is difficult to subject them to the same levels of oversight and accountability as open government and commercial activities. This makes it easier for dangerous practices and environmental hazards to continue unchecked. In addition, nuclear weapons are often seen as necessary to meet an urgent national security threat, meaning top priority will be given to producing weapons quickly. This can lead facilities to cut corners at the expense of safety considerations and to postpone efforts to deal with any long-term problems that may be developing.

Finally, as Arjun Makhijani observes, nuclear weapons programs inherently entail a "readiness to harm people."[84] Nuclear deterrence requires states to make credible a threat to kill perhaps millions of people if necessary. Once one has crossed the mental threshold to thinking in terms of so many potential civilian casualties, dangers that threaten the lives of "only" dozens or hundreds or even thousands of people may simply not register as significant.

In the following subsections, I first describe the unavoidable hazards in nuclear weapons work, then summarize the most significant types of accidents that nuclear weapon states might suffer. Next, I summarize what is known about the effects on worker health, followed by a discussion of the main risks that surrounding communities may confront. I conclude this review of environmental and health effects by evaluating the likelihood that new nuclear states can avoid these dangers.

HAZARDOUS MATERIALS CREATE INHERENT RISKS

The key to an independent nuclear capability is production of fissile materials: either plutonium or highly enriched uranium (HEU), or both. These materials,

84. Arjun Makhijani, "A Readiness to Harm," in *Nuclear Wastelands*, 6.

which are necessary to generate a nuclear explosion, can only be obtained through elaborate industrial processes. Plutonium, which does not exist in nature, must be created in a nuclear reactor and then chemically separated (a process known as "reprocessing") from other materials in the spent nuclear fuel. Naturally occurring uranium consists almost entirely of the nonfissile isotope U-238, so the initially slight percentage of fissile U-235 must be greatly increased through one of several known enrichment technologies. Of the two possible bomb-making materials, plutonium involves some especially serious risks that have historically caused the most harm of any aspect of nuclear weapons manufacturing. Creating HEU, however, also involves health and environmental risks.

Besides fissile materials production, a nuclear weapons program also involves research labs to design the weapons, facilities to produce other materials and components necessary to build bombs, and plants for the final assembly and disassembly of the weapons. These other facilities also typically create radioactive and toxic wastes and other hazards. Beyond the manufacturing process, problems can also arise when materials or finished weapons are in transport or storage or after weapons have been deployed.

Inherent risks arise because it is impossible to completely prevent human exposure to the hazardous materials involved in building nuclear weapons. Obviously, nuclear weapons' greatest difference from conventional arms is the role of substances that emit radiation: these include not only uranium and plutonium, but also decay products of these elements, other fission products created in plutonium production reactors, and tritium (hydrogen-3), which is often used as a neutron source to trigger or boost a nuclear explosive device. Plutonium is particularly carcinogenic if it gets into the body. The safe dose is about one seven-thousandth of a gram, so breathing in even a tiny particle of plutonium dust can cause cancer.[85]

Uranium poses more risk from its chemical than its radioactive properties (though it can also be a carcinogen). It is a toxic heavy metal that can cause kidney damage. In some processes a bomb-making program might employ, uranium is converted into the gaseous compound uranium hexafluoride. This gas is both toxic and highly corrosive, and when it touches water it breaks down, producing hydrofluoric acid, which can cause respiratory damage and severe burns.[86]

85. Bobbie Ann Mason, "Fallout: Paducah's Secret Nuclear Disaster," *New Yorker*, 10 January 2000, 33; David Sumner, Howard Hu, and Alistair Woodward, "Health Hazards of Nuclear Weapons Production," in Makhijani et al., *Nuclear Wastelands*, 99–100.

86. Arjun Makhijani and Scott Saleska, "The Production of Nuclear Weapons and Environmental Hazards," in *Nuclear Wastelands*, 42; Sumner et al., "Health Hazards," 95.

Nuclear weapons manufacture both requires and generates nonradioactive hazardous substances as well. One example is the metal beryllium, which is used as a tamper to reflect neutrons back into a plutonium warhead pit. Working with beryllium creates a high risk of various lung diseases, including an incurable condition similar to "black lung" disease. Obtaining lithium-6, which is used as a target in the creation of tritium and as a component in hydrogen bombs, requires large quantities of mercury to separate the lithium-6 from other lithium isotopes. Exposure to even small amounts of mercury can lead to neurological damage. Making nuclear weapons also requires using organic solvents that can damage the brain, nervous system, liver, kidneys and skin; some of these solvents are also carcinogenic.[87]

DANGERS FROM ACCIDENTS

The radioactive and toxic substances associated with nuclear weapons programs create some health risks whenever they must be handled or disposed of as waste. Beyond this, they also make possible certain kinds of accidents, and even when they are not a direct cause of accidents they can make them more deadly. Even though these accidents can cause significant harm, no existing nuclear weapon state has completely succeeded in avoiding them.

Plutonium reprocessing leads to probably the most difficult problems, because it creates vast quantities of highly radioactive liquid waste. This high-level waste (HLW) can be a source of health threats even when there are no accidents, but it also creates a risk of catastrophic accident. In order to contain material with such a high radiation level, plutonium reprocessing complexes usually store their HLW in steel tanks, but this also produces a risk of a massive explosion. The wastes generate hydrogen gas and, depending on the chemicals stored in the tank, may produce other gases as well. If these gases are not properly vented, or a ventilator system breaks down, or a cooling system fails allowing gases to build up too rapidly, the tanks can explode.[88]

A major tank explosion occurred in the Soviet Union in 1957 at the Mayak (meaning beacon or lighthouse) plutonium production facility. Mayak is located near the southeastern edge of the Ural Mountains in a complex formerly known as Chelyabinsk-65, the oldest of three complexes the Soviet Union built for obtaining plutonium. In the 1957 accident, one tank exploded with an estimated force of 70–100 metric tons of TNT, spewing out waste products with a

87. Len Ackland, "Who the Hell Will Insure Us?" *Bulletin of the Atomic Scientists* 48, no. 9 (November 1992): 22; Makhijani and Saleska, "The Production of Nuclear Weapons," 60–61; Sumner et al., "Health Hazards," 79–81, 99.

88. Makhijani and Saleska, "The Production of Nuclear Weapons," 53–55.

radioactivity of 20 million curies (for comparison purposes, the 1986 Chernobyl accident released 50 million curies according to the Soviet government). Radioactive fallout from the blast contaminated 15,000 to 23,000 square kilometers of land. In the most radioactive zone, all the trees were killed or damaged. Guards and cleanup crews were exposed to many times the maximum permitted radiation dose, and there are reports that a high percentage of the most heavily exposed died prematurely. Even today, 75 square miles remain uninhabitable.[89]

The United States has experienced the possibility of a similar accident at two sites: Hanford, which was the first U.S. plutonium production site, and the Savannah River Site, which produced both plutonium and tritium. At Hanford, in Washington State, estimates suggest two dozen to four dozen high-level waste tanks are at risk of explosion or fire. Hydrogen gas buildup in one tank led to "burping" until special measures were taken to reduce hydrogen accumulation. At the Savannah River Site in South Carolina there are two documented cases of hydrogen buildups in HLW tanks above the lowest threshold for a possible explosion.[90]

Similar near misses have also occurred in France and Britain. France's main plutonium reprocessing facility is located at La Hague, in northwest France along the English Channel. This facility has experienced at least two serious power outages. La Hague, however, relies on electricity to maintain cooling of its HLW tanks, and a power failure of just three to twelve hours, it is estimated, could cause the contents to overheat and explode. One might hope that the chances of such a catastrophic accident would decline over time. Because of human error, however, there will always be risks. This is demonstrated by a recent incident at the Sellafield complex, a site on England's west coast not too far below Scotland, where the plutonium for Britain's weapons was produced. In January 2001, workers monitoring HLW tanks there ignored for three hours

89. Thomas B. Cochran and Robert S. Norris, "A First Look at the Soviet Bomb Complex," *Bulletin of the Atomic Scientists* 47, no. 4 (May 1991): 26–28; Albert Donnay et al., "Russia and the Territories of the Former Soviet Union," in Makhijani, *Nuclear Wastelands*, 333–37, 388–89; Office of Environmental Management, U.S. Department of Energy, *Closing the Circle on the Splitting of the Atom* (Washington, D.C., January 1996), 77 [hereinafter, *Closing the Circle*]. This last report gives a lower estimate, of 5–10 tons, for the force of the explosion, but does not indicate its sources. The Mayak facility was also once known as Chelyabinsk-40. The explosion is sometimes referred to as the Kyshtym accident, as Kyshtym was the closest city listed on Soviet maps.

90. Linda Rothstein, "Nothing Clean about 'Cleanup'," *Bulletin of the Atomic Scientists* 51, no. 3 (May/June 1995): 39; Arjun Makhijani et al., "The United States," in *Nuclear Wastelands*, 220–23, 249; *Closing the Circle*, 31–34.

alarms warning of a gas buildup, which could have led to the explosion of a tank containing 2,000 tons of highly radioactive waste.[91]

Waste tanks containing "red oil," a mix of uranium, plutonium and other radioactive substances in a complex chemical solution, can also explode if the contents are not stirred adequately. The United States has suffered four red oil explosions, most recently at Savannah River in 1975. A 1959 explosion at Oak Ridge, a complex in Tennessee that processed uranium and lithium for nuclear weapons, spread 600 milligrams of plutonium in the vicinity of the building where the explosion occurred. A more serious red oil explosion happened in April 1993 at Russia's Tomsk-7 plutonium production complex in southern Siberia. This explosion spread radioactive contamination over 250 square kilometers. Less than a kilometer from the closest village, the radiation reached 40 times the natural background level.[92]

Besides waste tank explosions, two other types of accidents have occurred in association with fissile materials production: fires and criticality incidents. Both plutonium and uranium can trigger both types of accident. First, in their metallic form, both plutonium and uranium are flammable when small chips or flecks of them are exposed to air. Hence, fires have been a recurring problem in nuclear weapons production. Literally hundreds of fires broke out at the Rocky Flats Plant in Colorado, which made the plutonium pits for U.S. nuclear weapons; several of these fires released radioactive contamination. In the largest fire, in May 1969, only a lucky fluke saved the city of Denver, located sixteen miles downwind of Rocky Flats, from being exposed to a major plutonium release. The fire was drawn upward by large ventilator fans, until it nearly burned through the roof of the building. Disaster was averted only because a fire truck accidentally knocked over a power pole, cutting off electricity to the fans. Nevertheless, in fighting the fire, forty-one firefighters and plant workers sustained radiation doses.[93]

Fires and explosions can occur for other reasons as well. Great Britain's Sellafield site (known as Windscale at the time) experienced a serious fire in October 1957. The plutonium production reactors at Sellafield were graphite moderated, and graphite, because it is carbon-based, can catch fire if heating is

91. Donnay and Kuster, "France," 474; Terje Langeland, "Here, There, Everywhere," *Bulletin of the Atomic Scientists* 57, no. 6 (November/December 2001): 63–64. Nowadays, most of the work at both La Hague and Sellafield is for the civilian sector, but both sites also do reprocessing for their countries' nuclear weapons programs.

92. Makhijani et al., "The United States," 233; Donnay et al., "Russia," 358–60.

93. Len Ackland, "The Day They Almost Lost Denver," *Bulletin of the Atomic Scientists* 55, no. 4 (July/August 1999): 58–65; Makhijani et al., "The United States," 241–42; David Albright, "Secrets that Matter," *Bulletin of the Atomic Scientists* 56, no. 6 (November/December 2000): 61.

not properly controlled; this is apparently what happened in 1957. The fire caused two major releases of radioactivity. Studies estimate that the doses received by the public could have caused hundreds of thyroid cancer cases, including up to 100 fatal cancers.[94] Because graphite is considered the preferred moderator for plutonium production, new states that seek to develop a source of military plutonium will likely experience similar fire risks.

Fissile materials production can also lead to an accidental criticality. A criticality occurs when enough fissile material (which can be as little as half a kilogram) is brought together in a small enough space to trigger a chain reaction. Accidental criticalities will not cause a nuclear explosion, but will produce intense radiation for as long as the nuclear reaction continues. One study identified a total of nine criticality accidents in the United States since 1945; remarkably, eight of these took place in the nuclear weapons complex and only one in the civilian sector. Four people died within days of these accidents due to radiation exposure.[95] People who worked at the Mayak plant in the former Soviet Union remember four criticality accidents between 1957 and 1968. They report that all but one of those exposed in the accidents died as a result.[96]

The Israeli Atomic Energy Commission has acknowledged that an accidental criticality in December 1966 killed one person and injured three others at the Dimona complex in the Negev Desert where Israel does most of its nuclear weapons work. Other reports claim that several scientists have been killed by plutonium-related accidents at Dimona. The Israeli experience also suggests that further problems can arise if weapons production goals lead a country to continuing operating an aging reactor beyond its normal lifetime. A former Dimona scientist claims the reactor there is past the usual decommissioning age and has become unsafe as a result.[97]

Even the Chinese government, despite its penchant for secrecy, has acknowledged accidents. One official published an article that said ten people were exposed to radiation in a serious accident during the Cultural Revolution at an unnamed production reactor in northwest China (probably Jiuquan, which is the main plutonium production site in that area). Another official re-

94. David Sumner, Rebecca Johnson, and William Peden, "The United Kingdom," in Makhijani, *Nuclear Wastelands*, 417–19, 434.

95. Matthew L. Wald, "Nuclear Plant Safety Rules Were Broken, Inquiry Finds," *New York Times*, 18 October 1999, A12; Robert Alvarez, "Energy in Decay," *Bulletin of the Atomic Scientists* 56, no. 3 (May/June 2000): 28.

96. Vladislav Larin, "Mayak's Walking Wounded," *Bulletin of the Atomic Scientists* 55, no. 5 (September/October 1999): 27.

97. Cohen, *Israel and the Bomb*, 239 and 405 n. 65; Albert Donnay and Arjun Makhijani, "Near-Nuclear and De Facto Nuclear Weapons Countries," in *Nuclear Wastelands*, 566; Merav Datan, "Relaxing the Taboo: Israel Debates Nuclear Weapons," *Disarmament Diplomacy*, no. 43 (January/February 2000), http://www.acronym.org.uk/dd/dd43/43israel.htm.

port said careless handling of radioactive materials led to accidents that killed twenty people and injured 1,200 between 1980 and 1985. A government-sponsored newspaper also reported a 1988 accident that exposed fifteen people to radiation.[98]

Dangerous accidents can also occur, and indeed have occurred, after nuclear weapons have been assembled. For example, warheads contain chemical high explosive, which is used to compress the fissile materials into a critical mass. If part of this explosive is accidentally detonated, it can break open the warhead and disperse its radioactive contents, exposing people in the surrounding area to radiation.[99]

Such incidents can also have implications for stability, the traditional focus of the proliferation debate. In fact, Sagan has analyzed how an accident that caused a warhead to break open and disperse radioactivity could falsely be taken as an indication of nuclear attack and trigger a decision to launch nuclear weapons.[100] This section has shown that accidents can have quite negative effects even if they do not undermine stability. At the same time, once environmental consequences are considered seriously in their own right, fuller examination reveals that there are many possible accidents besides a warhead breaking open that could generate an explosion or radiation release that could be mistaken for evidence of an enemy attack.

HEALTH CONSEQUENCES FOR WORKERS

Even if no major accidents occur, workers at nuclear weapons plants cannot entirely avoid exposure to hazardous materials. Estimating the consequences for either employees or nearby residents is extremely difficult, however. Available raw data have significant gaps because nuclear weapons facilities did not always monitor releases of harmful substances or worker exposures to radiation, and when they did they often kept poor records or simply kept their data secret. In addition, there is still significant disagreement about the impact of exposure to low levels of radiation. As a result, there is no way to estimate with confidence any precise figure for the number of people killed or made sick by exposures resulting from nuclear weapons production.

Reflecting this uncertainty, studies to date of the possible health consequences have produced conflicting findings. The trend, however, has been

98. Alexandra Brooks and Howard Hu, "China," in Makhijani, *Nuclear Wastelands*, 517–18.

99. For a discussion of some U.S. cases, see Chuck Hansen, "The Oops List," *Bulletin of the Atomic Scientists* 56, no. 6 (November/December 2000): 65–66, and Schwartz, *Atomic Audit*, 408–11.

100. Sagan, *The Limits of Safety*, 156–203.

toward increasing evidence of certain negative health impacts. In 1999, after a thorough review of the existing studies, the U.S. government officially acknowledged that workers in the U.S. nuclear weapons complex had been harmed by exposure to radioactive and toxic substances. The study concluded that employees from fourteen facilities had elevated cancer rates and that they suffered from greater than expected rates of twenty-two categories of disease. As a result, Congress the next year approved legislation to compensate workers whose health had been affected and the families of workers who had died as a result. The Department of Energy (DOE), which has responsibility for the nuclear weapons complex, estimated that 3,000 cases would qualify for compensation: about one half for cancer and another one quarter for beryllium disease. Nongovernmental experts, however, believe the government's estimate is too low and that examination of a wider range of illnesses would reveal that thousands more workers suffered adverse health effects.[101]

Meta-analyses of the combined data from multiple nuclear weapons facilities tend to support the conclusion of an increased cancer risk. The evidence is strongest for elevated rates of leukemia and brain cancer, but higher than expected rates of all forms of cancer appear in the data. Separate studies in the United Kingdom found an increase in leukemia rates associated with greater exposure to radiation among nuclear weapons workers, and greater than expected death rates from prostate and renal cancers at certain facilities.[102]

On the other side of the ledger, nuclear weapons work also created jobs for individuals who might not otherwise have been able to find an equivalent source of income. In the former Soviet Union, for example, nuclear weapons workers enjoyed more amenities than the typical Soviet citizen. In many cases, nearby towns also achieved a higher standard of living because of the money nuclear weapons facilities injected into the local economy.[103] If the governments concerned had viewed creating employment or economic growth as an objective, however, they could have invested the vast sums of money spent on nuclear weapons in other activities. In this way, they might have been able to generate at least as many jobs, in less hazardous lines of work.

101. Matthew L. Wald, "Weapons Work Had Role in Illness, Government Says," *New York Times*, 15 July 1999, A12; Matthew L. Wald, "U.S. Acknowledges Radiation Killed Weapons Workers," *New York Times*, 29 January 2000, A1, A11; Matthew L. Wald, "U.S. Outlines Plan to Settle Claims of Bomb Plant Workers," *New York Times*, 13 April 2000, A19; "U.S. Nuclear Workers," a special section of *Bulletin of the Atomic Scientists* 57, no. 4 (July/August 2001): 38–60.

102. Makhijani et al., "The United States," 278–82; Sumner et al., "The United Kingdom," 426–28.

103 Dalton et al., *Critical Masses*, 61, 65, 290.

OFF-SITE CONTAMINATION PROBLEMS

Nuclear weapons production not only creates hazards for workers but also endangers people (and other living things) beyond site boundaries. There are three basic sources of risk: major accidents, intentional releases of hazardous materials, and inadvertent contamination. Since the risk of major accidents has already been discussed, this subsection will summarize the most likely and significant risks from the other two sources. Some practices and technologies from the early years of the nuclear age that involved large radiation releases can be avoided by new nuclear states if they choose and so will not be included here as anticipated consequences of proliferation.[104] Some intentional discharges into the air or nearby bodies of water, however, are still likely as a way to prevent contaminants from accumulating in dangerous concentrations inside nuclear weapon production sites, and these will necessarily release contaminants off site.

In addition, various operations also tend to cause on-site contamination, which can affect every element of the environment. According to the DOE, "Every site in the [U.S. nuclear weapons] complex is contaminated to some extent with radioactive or other hazardous materials. This contamination occurs not only in buildings; it is also found in soil, air, ground water, and surface water at the sites."[105] A 1994 French survey similarly determined that many sites in that country's nuclear weapons complex are contaminated.[106] Some of this contamination is also likely to migrate off site.

Britain's Sellafield complex illustrates how intentional and inadvertent releases can combine to produce problems. Sellafield deliberately discharged some wastes into the nearby Irish Sea in the belief that the sea would disperse and dilute the radiation. Other contamination arose unintentionally, because wastes stored in ponds on site washed out to sea and radioactive liquids leaked from buildings used to store fuel cladding.[107]

These releases are strongly suspected of causing major health problems. In the village of Seascale, near Sellafield, the leukemia rate is ten times the national average (because researchers disagree about the cause, this cluster cannot be definitively attributed to Sellafield). Some radiation researchers have estimated that Sellafield's emissions will over the lifetime of the radioactivity lead to 200 excess cancer deaths for each year the emissions remain at their

104. Details of the most egregious examples can be found in Makhijani et al., *Nuclear Wastelands*; and Dalton et al., *Critical Masses*.

105. *Closing the Circle*, 61.

106. Larkin, *Nuclear Designs*, 259.

107. Sumner et al., "The United Kingdom," 413–17; Larkin, *Nuclear Designs*, 254–58, esp. n. 8.

current level. Besides the Seascale cluster, leukemia clusters have developed near other nuclear weapons production sites in Europe. U.K. researchers have identified a cluster in the Reading area, a location near both the Aldermaston weapons lab and the Burghfield plant, which did the final assembly and disassembly of Britain's nuclear bombs. Researchers in France also found elevated leukemia rates in the vicinity of the La Hague reprocessing plant. They found that leukemia is most likely among children who went regularly to local beaches or who ate local seafood. Because radioactivity accumulates in greater concentrations in fish and shellfish than in the surrounding water, those who consume fish from contaminated portions of rivers or the sea will be at greater risk.[108]

Plutonium production and reprocessing, as at Sellafield and La Hague, create the greatest radioactive contamination problems. Even if countries eschew the plutonium path to the bomb, however, they will still have to engage in other production processes that can produce significant contamination. In the United States, the Fernald Plant in southwestern Ohio processed uranium for use in enrichment as well as in production reactors. In its work with uranium metal, Fernald emitted about 300 metric tons of uranium dust into the air. Uranium from Fernald also contaminated the drinking-water wells of nearby residents. Radon-222 gas releases from on-site waste storage tanks were also sufficient to create a risk of lung cancer among those most exposed comparable to that produced by smoking cigarettes.[109]

Nonradioactive toxic substances have also been routinely discharged into the environment. For example, Oak Ridge released an estimated 1,000 tons of mercury, which was used in lithium separation. Much of this was discharged into a nearby creek, and mercury concentrations well above EPA limits have been discovered in a nearby pond. Creek waters that feed into the Clinch River are also contaminated with radioactive cesium-137 and strontium-90 as well as PCBs from Oak Ridge.[110]

108. Sumner et al., "The United Kingdom," 430–31; Ian Fairlie and Marvin Resnikoff, "No Dose Too Low," *Bulletin of the Atomic Scientists* 53, no. 6 (November/December 1997): 56; Anita Seth, "Leukemia Clusters Near La Hague and Sellafield," *Energy and Security*, no. 4 (Institute for Energy and Environmental Research, February 1998), http://www.ieer.org/ensec/no-4/lahague.html; Dalton et al., *Critical Masses*, 42–44. Both Sellafield and La Hague have been used for civilian as well as military purposes, so it is unclear what percentage of their negative health impacts should be attributed to nuclear weapons. However, they still serve to illustrate the kinds of problems future states might encounter if possible weapons goals lead them to build either a dual-use or a dedicated military plutonium production complex.

109. *Closing the Circle*, 61; Schwartz, *Atomic Audit*, 413–14.

110. *Closing the Circle*, 61, 63; Makhijani et al., "The United States," 233.

Even when production complexes attempt to contain or dispose of wastes on site, such efforts are often unsuccessful, due to leaks, spills or faulty calculations of how well a disposal method will work. Such miscalculations can open the door to especially disastrous developments, as the Soviet experience illustrates. In the early years of plutonium production at its Mayak plant, the Chelyabinsk-65 complex actually dumped the wastes from Mayak directly into the Techa River, but stopped in the 1950s after the radioactive contamination this produced forced the evacuation of many downstream villages. Since, one hopes, no new nuclear state will simply dump its most radioactive wastes into a river, what happened subsequently, after Mayak began trying to manage its wastes, is more relevant to determining the possible consequences of future proliferation. Although it stored most HLW in tanks (one of which exploded in the 1957 accident described above, itself a tragic example of one of the greatest environmental risks), Mayak diverted medium-level wastes into nearby Lake Karachay, an enclosed body of water with no outlets. After an unusually dry winter and spring, strong winds in April and May 1967 blew radioactive dust from dried-out portions of the lakebed over a wide area. Reports of the radioactivity released and territory affected vary greatly, but an intermediate estimate used by a U.S. government official suggests the wind dispersed 600,000 curies over 2,700 square kilometers. By the early 1990s, because of the cumulative waste discharged into it, one portion of Lake Karachay had become so radioactive that a person standing at the lake's edge would receive a lethal dose in less than one hour.[111]

Visitors to the region have reported that the Chelyabinsk Children's Hospital has a complete ward devoted to leukemia cases, and studies in the early 1990s found elevated rates of thyroid cancer and other diseases in the area around Mayak that they attributed to radiation releases. In an eerie symbol of the continuing danger of major radiation releases, in the town of Kyshtym, fifteen kilometers west of Mayak, a digital sign flashes not only the time and temperature, but the current radiation level as well.[112]

111. Donnay et al. "Russia," 326–33; Commissioner Greta Joy Dicus, U.S. Nuclear Regulatory Commission, "Joint American-Russian Radiation Health Effects Research" (presentation to the joint meeting of the American Nuclear Society, Washington, D.C. Section, and the Health Physics Society, 16 January 1997, Baltimore-Washington Chapter, http://www.posse.net/dicus/s-97-04.htm). Donnay et al. and Dalton et al. (79) provide a much lower estimate, that the wind spread 600 curies over 1,800 square kilometers. Two other sources present a much higher estimate, suggesting five million curies were dispersed over 25,000 square kilometers. See Mark Hertsgaard, Earth Odyssey: Around the World in Search of Our Environmental Future, chap. 4, "To the Nuclear Lighthouse," http://www.whistleblower.org/www/odyssey.htm; "The Most Contaminated Spot on the Planet: Chelyabinsk Nuclear Disasters," http://www.logtv.com/chelya/cheldis.html.

112. Dalton et al., *Critical Masses*, xvi, 59, 81.

Waste management practices at other Soviet plutonium-production sites reveal other potential contamination risks. Starting in the 1960s, both Tomsk-7 and Krasnoyarsk-26 began injecting most of their high-level waste deep underground, hoping to contain it in or between layers of clay and sand found under the sites. This has led to groundwater contamination that could migrate to nearby rivers and sources of drinking water. At Tomsk-7, the wastes were deposited at a depth that may be within fifty meters of groundwater that supplies water for the city of Tomsk; the site is also about ten to twelve kilometers from the Tom River. Moreover, the rock in this area is very wet, which increases the chances of migration of waste materials. Some Russian scientists and officials claim the site's geology will safely contain the waste materials, but there are also reports that village wells seven to fourteen kilometers away have already been contaminated by radionuclides. At Krasnoyarsk-26, wastes were injected in a terrace one-hundred meters above and just seven-hundred-and-fifty meters from the Yenesei River. Studies have found localized contamination and migration into groundwater here as well, though again officials claim the migration will not be rapid enough to pose a risk.[113]

Many U.S. sites have experienced similar difficulties confining wastes placed in on-site repositories. At Hanford, sixty-seven HLW storage tanks are confirmed or suspected to have leaked. The government believes at least 750,000 gallons of highly radioactive waste got into the soil as a result. Some of this waste has reached the water table, and the DOE estimates it will migrate to the nearby Columbia River within about twenty years.[114] The DOE has also expressed great concern about water contamination risks at the Pantex plant, near Amarillo, Texas, which has been responsible for final assembly and disassembly of U.S. nuclear weapons. Pantex is only one-hundred-and-fifty meters above the Ogallala Aquifer, the largest and most heavily used aquifer in the United States. Until 1980, Pantex dumped its chemical wastes in unlined pits, creating a danger that toxics will migrate into groundwater.[115] The contractor that operated the Savannah River Site has acknowledged that groundwater there is contaminated with plutonium. Environmental scientists have expressed concern that the plutonium and other contaminants will migrate into

113. Donnay et al., "Russia," 344–45, 356–57, 362–63;. U.S. Office of Technology Assessment, *Nuclear Wastes in the Arctic* (Washington, D.C.: GPO, September 1995), 42; Dalton et al., *Critical Masses*, 79, 371; Don J. Bradley, Clyde W. Frank, and Yevgeny Mikerin, "Nuclear Contamination from Weapons Complexes in the Former Soviet Union and the United States," *Physics Today* 49, no. 4 (April 1996): 43–44.

114. Schwartz, *Atomic Audit*, 361; Dalton et al., *Critical Masses*, 329. The leakers are all older, single-walled tanks. Newer double-walled tanks have not leaked.

115. Makhijani et al., "The United States," 238.

the Tuscaloosa Aquifer, a source of drinking water for Alabama, Georgia, and the Carolinas.[116]

Some off-site contamination risks are truly surreal. Workers at Hanford regularly collect and bury what they call "hot tumbleweeds," which grow in the contaminated soil at the site. One reason there is concern about vegetation in contaminated areas is that it would release radioactivity if burned in a fire. Events in 2000 demonstrated that this concern is not farfetched. In May a fire that had been set to clear brush burned out of control and threatened the Los Alamos National Laboratory. Then, in late June, an auto accident triggered a fire that swept across half of the Hanford Nuclear Reservation. Both fires led to slight releases of radioactivity, much of it attributed to the burning of contaminated vegetation, though the radiation in both cases remained below levels officials consider hazardous to health. Both fires also threatened buildings or storage sites containing much greater levels of radioactivity, and major releases were averted mainly due to favorable changes in the wind.[117]

The primary concern in this section is the health harm that can arise from nuclear weapons production, but it is worth noting that the environmental consequences also add substantially to the economic costs of becoming a nuclear state. In 1995, the Energy Department estimated that a comprehensive cleanup of the U.S. nuclear weapons complex would cost $500 billion; others have estimated that it will require $1 trillion. If the United States decides not to clean up the sites, it will still have to spend about $200 billion over seventy-five years to stabilize the sites so as to limit future off-site migration of contaminants.[118] The Congressional Budget Office has estimated that compensating workers or their families for illnesses linked to weapons work will cost a further $2 billion in the program's first decade.[119] In the end, dealing with the environmental and health consequences of a nuclear weapons program could cost a country as much money as building its arsenal in the first place.

This shows it is important to consider possible linkages between different types of consequences, such as economic and environmental. In addition, there can also be unfortunate interaction effects within a category. For

116. Ibid., 253; William Lanouette, "Weapons Plant at 40: Savannah River's Halo Fades," *Bulletin of the Atomic Scientists* 46, no. 10 (December 1990): 37.

117. Jon Christensen, "Unknowns Nag after Fires near Atomic Sites," *New York Times*, 12 September 2000, D3; "Fire Is Out at Hanford Reservation," photo caption, *New York Times*, 1 July 2000, A7; Keith Easthouse, "Too Close for Comfort," *Bulletin of the Atomic Scientists* 56, no. 5 (September/October 2000): 10–12.

118. Rothstein, "Nothing Clean about 'Cleanup'," 34; Dalton et al., *Critical Masses*, 305; "Nuclear Sites May Be Toxic in Perpetuity, Report Finds," *New York Times*, 8 August 2000, A12.

119. AP, "Payments to Begin for Arms Workers Ill from Radiation," *New York Times*, 30 July 2001, A12.

example, if environmental contamination must be cleaned up to avoid a threat to public health, the cleanup effort can create a new set of accidents and health hazards. Workers at Oak Ridge have charged that waste incineration there triggered a spate of unusual illnesses, while accidents during cleanup at Oak Ridge have created new exposures to hazardous materials as well as new contamination problems. Cleanup work at Hanford even exposed eleven workers to internal doses of plutonium, although the exposures were within regulatory limits.[120]

NEW NUCLEAR STATES UNLIKELY TO AVOID PROBLEMS

How likely is it that the harms outlined above will be replicated by future nuclear weapon states? Compared to weapon states of the first generation, future proliferants could benefit from greater awareness of the dangers of radiation, newer technology, and learning from the first generation's experiences. For reasons given above, however, I have argued that there are limits to how effective learning can be in reducing the hazards, and empirical evidence bears this out. Two sets of evidence, in fact, suggest that future programs are unlikely to be less harmful than past nuclear weapons efforts. First, even the states with the most advanced technology and greatest democratic accountability still experience accidents and sometimes disregard safety or environmental concerns. Second, the limited data available from the most recent aspiring proliferants also indicate serious health and environmental risks.

On the first point, the United States, Great Britain and France all still have recurring problems in their nuclear weapons complexes. In the United States, for example, Hanford during its final years of operation committed 17 violations of rules designed to prevent accidental criticalities. A DOE investigation discovered that in some cases supervisors had even told workers to ignore these rules.[121] In France, a discharge pipe from the La Hague reprocessing plant was releasing radioactive waste into the ocean near a public beach until at least June 2000.[122] In 1999, the U.K.'s Aldermaston plant admitted it had for two years illegally discharged radioactive waste (containing tritium) into a stream that feeds the Thames. The previous year, a safety audit of the plant

120. Michael Flynn, "A Debt Long Overdue," *Bulletin of the Atomic Scientists* 57, no. 4 (July/August 2001): 44–45; Len Ackland, "Rocky Flats: Closing in on Closure," *Bulletin of the Atomic Scientists* 57, no. 6 (November/December 2001): 54, 56; Langeland, "Here, There, Everywhere," 62.

121. Alvarez, "Energy in Decay," 25, 29; Wald, "Nuclear Plant Safety Rules Were Broken, Inquiry Finds."

122. Bret Lortie, "Web Watch," *Bulletin of the Atomic Scientists* 56, no. 5 (September/October 2000): 9.

revealed three "serious" safety violations, including one instance of failing to follow "criticality clearance" procedures.[123] Even more seriously, as noted above, there was nearly an HLW tank explosion at Sellafield in early 2001. If even the most experienced, technologically advanced and democratic nuclear weapon states still cannot achieve a clean safety and environmental record, one cannot expect newcomers to the nuclear club to do any better.

In fact, serious problems are likely. Many of the more recent nuclear acquisition efforts have occurred in countries that have troubled economies, less modern technology, and unstable or authoritarian governments. It is unlikely that workers or the public in these countries will be well protected against the hazards of nuclear weapons production.

Iraq offers a stark example of how weak efforts to safeguard workers' health may be in new nuclear states. According to Peter Zimmerman, "even by Manhattan Project standards their precautions were primitive and inadequate to protect the majority of workers." David Kay, who led some of the first international inspections of Iraq after the 1991 Gulf War, has reported that some American inspectors initially did not believe that nuclear weapons work had gone on at certain sites because the facilities could never have met U.S. Occupational Safety and Health Administration (OSHA) standards for handling radioactive materials. While Kay tells the anecdote to make fun of the naïveté of some U.S. scientists, the story also gives some indication of just how bad conditions must have been for those working on Iraq's nuclear weapons program.[124]

Iraq also illustrates how stability considerations can interact with health and environmental issues. After Iraq's invasion of Kuwait, Saddam Hussein ordered an all-out effort to try to complete a nuclear device before the United States and its allies could initiate use of force against Iraq. To produce needed material, the Iraqis ran one of their reactors nonstop for so long it irradiated the plant and workers there became ill with radiation sickness.[125] If a state's progress toward a nuclear capability does not lead to stability, or even encourages aggression by that state, then the pressures of expected conflict can exacerbate the other negative consequences of proliferation.

123. Charles Arthur, "Nuclear Waste Fed into Thames Stream," *Independent*, 14 December 1999, http://www.independent.co.uk/news/UK/Environment/nuclear141299.shtml; Andrew Gilligan and Rob Evans, "Aldermaston Report Reveals String of Alerts over Safety," *Daily Telegraph*, 21 February 1999, http://www.telegraph.co.uk.

124. Peter D. Zimmerman, "Technical Barriers to Nuclear Proliferation," *Security Studies* 2, nos. 3/4 (spring/summer 1993): 348; David Kay, "Iraqi Inspections: Lessons Learned" (talk given at the Monterey Institute of International Studies, 10 February 1993, reprinted in *Eye on Supply*, issue 8 (winter 1993), http://cns.miis.edu/db/archives/nuc/eos/kay.htm.

125. Hamza, *Saddam's Bombmaker*, 237.

North Korea has also experienced significant environmental and safety problems in its main nuclear complex at Yongbyon. When they selected the site, planners failed to account for the maximum height reached by the nearby Kuryong River during the late summer rainy season. As a result, basement rooms in the complex have repeatedly been flooded. In fall 1995 basements of the critical assembly and nuclear fuel storage facilities in one part of the complex were completely flooded. International Atomic Energy Agency (IAEA) inspectors and other observers have expressed concern about the potential for accidents at the site and about the physical security of its nuclear materials. IAEA officials have also indicated that North Korea's radiation shielding systems are "inferior to those of the advanced countries." In addition, North Korea lacked the ability to prevent the corrosion of spent fuel from its graphite-moderated reactor (the reactor from which the IAEA suspected plutonium had been diverted). Considerable contamination could have resulted; it was prevented only because fear that North Korea might remove and possibly reprocess the spent fuel led the U.S. government to send a team of nuclear engineers to put the spent fuel in canisters that would prevent corrosion.[126]

Isolated, authoritarian states are not the only recent aspirants to nuclear weapon status to experience serious problems. Although India is democratic and can draw on a greater base of scientific expertise, its safety record is not encouraging. India's dedicated nuclear weapons facilities are located in Trombay (just north of Bombay) at the Bhabha Atomic Research Center (BARC). India also has a number of primarily civilian facilities that supply materials to its military program.

Journalistic exposés have suggested a wide range of ongoing safety and environmental problems. A 1979 article reported that there had been two explosions at the Baroda heavy water plant, as well as a major fire and pollution of well water at the uranium processing and fuel fabrication plant in Hyderabad. A more recent investigation charges that more than fifty workers involved in dumping wastes from Hyderabad into storage ponds died in a four-year period in the 1990s because of their radiation intake. Outside investigators also say there is evidence that excess radiation exposure among people living near India's nuclear facilities has led to abnormally high rates of cancer, birth defects,

126. Georgiy Kaurov, "A Technical History of Soviet-North Korean Nuclear Relations," in *The North Korean Nuclear Program: Security, Strategy, and New Perspectives from Russia*, ed. James Clay Moltz and Alexandre Y. Mansourov (New York: Routledge, 2000), 16; Alexandre Y. Mansourov, "The Natural Disasters of the Mid-1990s and Their Impact on the Implementation of the Agreed Framework," in ibid., 78–80; Donnay and Makhijani, "Near-Nuclear and De Facto Nuclear Weapons Countries," 568–69; Ryukichi Imai, "Asian Ambitions, Rising Tensions," *Bulletin of the Atomic Scientists* 49, no. 5 (June 1993), 35.

and infertility, especially in villages near plants where accidents have occurred.[127]

Nuclear plants that have a larger civilian than military role are not the only ones with a poor safety record. India's nuclear weapons complex appears to function no better. For example, in 1991 BARC operated its Dhruva plutonium-production reactor for almost a month with a malfunctioning emergency cooling system. In 1995, an accident started draining water from a fuel-rod storage pond, nearly exposing the radioactive fuel rods to air. Multiple leaks in underground pipelines at BARC have also contaminated a large volume of subsoil with radioactive liquid waste.[128]

Breaking with a tradition of minimal oversight, in 1995 the then-chairperson of the Atomic Energy Regulatory Board (AERB), Adinarayana Gopalakrishnan, initiated a comprehensive review of safety at India's nuclear installations. Although the Indian government used official secrecy laws to prevent public release of his report, Gopalakrishnan later told the press about its general findings. Speaking about certain facilities at BARC, he said their "degraded safety status and continued operation without substantial repairs have been causing serious concerns within the AERB from the standpoint of worker and public safety." Despite these concerns, in April 2000, the Indian government removed BARC from further AERB oversight, raising further concerns that safety standards would not be adequately enforced.[129]

One other small incident symbolizes how governments come to accept harm to local communities in order to move forward in nuclear weapons development. India's Pokaran test site is located in a desert, where about 20,000 people live in nearby villages. The desert residents depend on stored water, and sometimes pay more for their water tanks than for their homes. When India tested nuclear weapons in May 1998, the tests cracked a number of these water tanks, putting at risk the water supply for local villagers.[130]

127. Dhirendra Sharma, *India's Nuclear Estate* (New Delhi: Lancers, 1983), 120; T. S. Gopi Rethinaraj, "In the Comfort of Secrecy," *Bulletin of the Atomic Scientists* 55, no. 6 (November/December 1999): 56; Donnay and Makhijani, "Near-Nuclear and De Facto Nuclear Weapons Countries," 562; Raju G. C. Thomas, "India's Energy Policy and Nuclear Weapons Program," in SarDesai and Thomas, *Nuclear India*, 282, 295.

128. Donnay and Makhijani, "Near-Nuclear and De Facto Nuclear Weapons Countries," 562; Rethinaraj, "In the Comfort of Secrecy," 55–56.

129. Rethinaraj, "In the Comfort of Secrecy," 56; Ramola Talwar Badam, "India's Nuke Program More Secretive," Associated Press, 31 May 2000; Gopalakrishnan quoted in "Wisdom of Action Questioned," *The Hindu*, 2 June 2000.

130. "The Buddha Smiled a Cracked Smile," *Rediff on the Net*, 16 May 1998, http://www.rediff.com/news/1998/may/16bomb4.htm. I thank Gaurav Kampani for bringing this story to my attention. During a talk I attended in May 2001, a former high-level scientist in India's nuclear weapons program confirmed that the 1998 tests caused cracks in nearby villages.

PSYCHOLOGICAL CONSEQUENCES

Nuclear weapons gain their deterrent effect by creating a risk of enormous destruction; they can also be potent symbols of military power. For these reasons, they may have significant effects, either positive or negative, on peoples' psyches in countries that develop nuclear weapons. Because security is partly subjective—a question of whether or not one feels safe—the possible benefits of nuclear weapons would be reduced if they create feelings of insecurity, and vice versa. Psychological impacts could also affect the net utility of nuclear weapons for a society in other ways.

On the positive side, nuclear weapons may create feelings of national pride, as signs of scientific accomplishment and a means to stand up to outside powers. After India's first nuclear test, in 1974, a public opinion poll found that 90 percent of those who knew of the test were "personally proud of this achievement."[131] Following the May 1998 tests, people gathered near the prime minister's residence, where they danced in the streets and shouted "Victory to Mother India!"[132]

In countries that have lived with the mutual threat of annihilation for some time, however, psychological research shows that there are also negative impacts. A series of studies in the late 1970s and early 1980s examined the psychological effects on children and adolescents of living with the possibility of nuclear war. These studies produced consistently similar findings; although most were conducted in the United States, a small number conducted in the Soviet Union and others in Europe corroborated the U.S. findings.[133] The studies found awareness of the possibility of nuclear war in children as young as five or six years old. The overriding response produced in children was fear for the future. Many children also expressed feelings of powerlessness, leading them to conclude that participating in the political arena would not be worthwhile. In some, their fears also made them unwilling to make long-range plans, out of a belief they might not survive to enjoy the benefits.

This psychological unease can continue into adulthood. Research in the 1970s on Americans who had experienced air raid drills as children found that

131. Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security* 21, no. 3 (winter 1996/97): 68. The same poll found that 91 percent of the literate adult population knew of the test.

132. John F. Burns, "India Charts a Perilous Course to Glory," *New York Times*, 17 May 1998.

133. The studies through the mid-1980s are listed, and their overall findings summarized, in William R. Beardslee, "Children's and Adolescents' Perceptions of the Threat of Nuclear War: Implications of Recent Studies," *The Medical Implications of Nuclear War*, ed. Fred Solomon and Robert Q. Marston (Washington, D.C.: National Academy Press, 1986): 413–34.

all of them had occasional nightmares about nuclear war.[134] The psychologist Robert Jay Lifton argued that awareness of the bomb had become to some extent always present in people's minds, potentially coloring every aspect of their lives. Controversially, Lifton claimed that Americans were suffering from "psychic numbing": because people can no longer be certain that any of their works will last or that their descendants will survive into the future, and because worrying constantly about nuclear war would be overwhelming, people had to numb some of their ability to feel in general.[135] Even if one does not accept Lifton's thesis *in toto*, it seems reasonable to expect that a loss of certainty about the existence of a human future would be emotionally unsettling.

On the other hand, people could also experience fear if a potential adversary had nuclear weapons but their own state did not. Because nuclear weapons have dualistic implications, as discussed above, the psychological effects could similarly run in opposite directions. Hence, while some people have nightmares or numb their feelings because they fear nuclear war, others might feel more secure because they believe nuclear deterrence provides a guarantee of security their country could not achieve through any other means.[136]

Finally, the psychological effects on society can have negative implications for the stability of deterrence. The mix of fear and nationalism aroused by a demonstrated nuclear capability tends to work against the caution that optimists expect nuclear weapons to produce. Praful Bidwai is the leading journalistic critic of India's nuclear weapons program. Two years after the 1998 test series, he observed: "Today, instead of sobriety, we have unprecedented exchanges of hostile rhetoric and heightening of tensions. The number of Indians who believe that Pakistan's destruction is a prerequisite for peace in this region (and vice versa) has never been greater." Bidwai contends that the revival in both countries of national prejudices against the other side has been one of the main costs of their declarations of nuclear weapon status.[137] If the public develops a more negative image of the other side at the same time it becomes more confident in its own country's strength, this is a recipe for recklessness, not caution.

134. Robert Jay Lifton and Richard Falk, *Indefensible Weapons: The Political and Psychological Case against Nuclearism* (New York: Basic Books, 1982), 48–50.

135. Ibid., passim.

136. This argument is purely speculative, however, as I am not aware of any studies showing that people feel less anxiety once their country obtains nuclear arms. I thank Nathan Busch for bringing this possibility to my attention.

137. Praful Bidwai, "Pokhran in Retrospect: The High Costs of Nuclearism," *Times of India*, 13 May 2000, http://www.timesofindia.com/130500/13edit4.htm. I thank Michael Barletta for bringing this article to my attention.

DOMESTIC POLITICAL CONSEQUENCES

Security for a state involves protecting the state's territory, the lives of its citizens, and the national institutions that are highly valued as part of the state's identity.[138] In democracies, preserving the democratic political system (and associated personal freedoms) is usually one of the state's goals. To the extent nuclear deterrence helps to protect freedom and democracy, its domestic political consequences will be seen as positive.

Nuclear weapons programs, however, can also have other consequences for the vitality of democratic institutions. Such programs tend to short-circuit normal mechanisms for ensuring debate, oversight, or accountability. Historically, decisions to initiate a nuclear weapons program have been made in secret by a very small inner circle of leaders.[139] Thus, even if a majority of a state's citizens might have voted not to develop a nuclear arsenal, they are never given a chance to register this preference in advance. In addition, neither the citizens nor the legislature in even the most democratic nuclear weapon states have been given much scope for input into questions of nuclear doctrine that could determine when and how a nuclear war is fought, even though such decisions literally involve the highest imaginable stakes: the survival of the country and its people.[140]

These problems are accentuated in opaque proliferators, which, in order not to provoke a strong international reaction, seek to keep the existence of their program either covert or at most ambiguous. In such countries, no aspect of the program, not even whether to keep a nuclear arsenal, can be debated publicly. As a result, even in democratic Israel, any publication on the nuclear issue is subject to strict military censorship. As Cohen and Frankel put it, "Opacity thus depends on a continuous voluntary subversion of democratic institutions."[141]

Concerns about preserving secrecy can also prompt harsh reactions by the state, with negative impacts on personal freedom and human rights. This is again especially true in opaque proliferators. In such countries, anyone who reveals details about the program, even if his or her goal is to permit public

138. Barry Buzan, *People, States and Fear*, 2nd ed. (Boulder: Lynne Rienner, 1991), chap. 2.

139. Brief summaries of the origins of various states' decisions to build nuclear weapons can be found in Larkin, *Nuclear Designs*, and Makhijani, *Nuclear Wastelands*.

140. Robert Dahl, *Controlling Nuclear Weapons: Democracy versus Guardianship* (Syracuse: Syracuse University Press, 1985). Richard Falk argues nuclear weapons create "structural necessities" that inherently contradict and corrode democratic governance ("Nuclear Weapons and the Renewal of Democracy," in *Nuclear Weapons and the Future of Humanity*, ed. Avner Cohen and Steven Lee [Totowa, N.J.: Rowman and Allenheld, 1986], 437–56).

141. Avner Cohen and Benjamin Frankel, "Opaque Nuclear Proliferation," *Journal of Strategic Studies* 13, no. 3 (September 1990): 33.

debate rather than to assist some other country, may face a severe legal response. In October 1986 Mordechai Vanunu, a nuclear technician, gave information about Israel's nuclear program to London's *Sunday Times*. Israeli agents subsequently kidnapped Vanunu in Italy and brought him back to Israel, where he was tried behind closed doors and sentenced to 18 years in solitary confinement for disclosing state secrets.

The handling of the Wen Ho Lee case in the United States also raises troubling questions. The case is different from Vanunu's in an important way: Lee, a scientist at the Los Alamos National Lab, was suspected of providing secret weapon design information to a rival government, which if true would be a real and undesirable case of espionage. The government's case, however, crumbled spectacularly. After charging Lee on fifty-nine counts, the government accepted a guilty plea on just one count, which did not involve giving away secrets, and it released Lee for time served. If the government's case was actually as weak as this outcome suggests, then the United States treated Lee unfairly in two respects. First, after his arrest, Lee was kept in solitary confinement, under relatively harsh conditions, for nine months. Second, because the investigation began after a discovery that China had obtained U.S. secrets, investigators assumed any spy would be ethnically Chinese, meaning Lee became a target at least in part because of his racial background.[142] Lee's unusually harsh treatment before he went to trial and the racial prejudices that allegations of Chinese espionage apparently aroused both suggest that fears about losing nuclear secrets can prompt law enforcement practices that would not otherwise be considered acceptable in a democracy.

Legitimate concerns about nuclear secrecy can also become a shield behind which to hide other undesirable practices. In countries that do not create separate military and civilian nuclear installations, laws to protect military secrets are easily stretched to protect the civilian nuclear sector from scrutiny. For example, India's Department of Atomic Energy has on numerous occasions invoked the Official Secrets Act and Atomic Energy Act to prevent the public release of information about performance failures and safety problems in the country's extensive civil nuclear program.[143] This is yet another example of

142. A Justice Department probe of how the DOE and FBI handled the Lee case "found no evidence of racial bias," but this seems to be purely a semantic distinction since the probe also acknowledged that government investigators relied on flawed assumptions that led them to make Lee their only suspect. Stephen I. Schwartz, "Scientist, Fisherman, Gardener…Spy?" *Bulletin of the Atomic Scientists* 56, no. 6 (November/December 2000): 31–38; Dan Stober, "Special Report: The Investigation of Wen Ho Lee," *San Jose Mercury News*, 17 and 18 December 2000; David Johnston, "Justice Dept. Cites Problems in 2 Inquiries at Los Alamos," *New York Times*, 14 August 2001, A14; Stephen I. Schwartz, "A Tragedy of Errors," *Bulletin of the Atomic Scientists* 58, no. 4 (July/August 2002): 61–64.

143. Sharma, *India's Nuclear Estate*; Rethinaraj, "In the Comfort of Secrecy."

how different types of consequences can interact in ways that further increase the negative impacts. In this case, a limitation on democratic oversight arising from a nuclear arms program can add to the health and environmental problems a country will experience.

The incentives for nuclear secrecy can also be a force working against the establishment of democratic practices in countries undergoing transitions away from autocracy. In the 1990s, Russia arrested a number of individuals who provided information about or protested against Russia's nuclear activities. Probably the most ominous cases involved the nuclear-powered naval fleet rather than nuclear weapons, but they illustrate what states are willing to do to shield military nuclear activities from scrutiny. In separate cases, two former naval officers were charged with treason for helping foreign groups investigate ocean dumping of nuclear waste by the Russian Navy. The conviction of one individual was eventually overturned on appeal, but the Supreme Court upheld a sentence of four years in a labor camp in the second case. In both cases, the Federal Security Service, the successor agency to the Soviet KGB, made the arrests. This suggests that the mission to preserve nuclear secrets can become a pretext for a former secret police organization to maintain a role for itself in a democratizing society.[144]

In a weakly institutionalized democracy, the consequences of crossing the nuclear threshold can even indirectly help topple democracy itself. The chief example is Pakistan, where the open demonstration of nuclear weapons capability helped set the stage for the military overthrow of its democratically elected government in October 1999. The majority of Pakistanis initially tolerated the coup by General Pervez Musharraf because of the widespread corruption attributed to the ousted prime minister, Nawaz Sharif. While this government corruption had no relation to nuclear weapons, the events that led to Sharif's ouster flowed directly from Pakistan's nuclear tests in 1998. Based on a belief that the stability-instability paradox would preclude a forceful Indian response, after the tests the army, under Musharraf's leadership, increased its involvement in the disputed Kashmir region, leading to the Kargil conflict. When Sharif gave in to U.S. pressure to withdraw Pakistani forces, opposition parties and much of the public and the military saw this decision as a humiliating cave-in. To deflect criticism, Sharif attempted to blame the military for the Kargil debacle and to remove certain military leaders from office. These actions then triggered the coup. Thus, in Pakistan, one can plausibly argue that

144. Dalton et al., *Critical Masses*, 359–62; Michael Wines, "Russian High Court Strikes Down Military Secrecy Order," *New York Times*, 13 February 2002, A13; AP, "Russian Court Upholds Reporter's Conviction," *Washington Post*, 26 June 2002, A17.

democratic government itself became a casualty of the nuclear weapons program.[145]

The Pakistani coup also shows once more how looking at a broader range of consequences of nuclear proliferation can add relevant information to the traditional focus of the debate, the prospects for stability. Because Indian officials perceive the Pakistani military as one of the most hardline anti-India elements in Pakistan, the coup led New Delhi to see less scope for conflict resolution and a greater need for hardline policies of its own. Although this was not the only factor involved, this perception contributed to India's willingness to threaten war following the attack on its parliament in December 2001. By weakening Pakistani democracy, nuclear weapons thus helped remove one of the sources of moderation on the subcontinent. The impacts of nuclear weapons on a country's economy and domestic political system are worth considering in their own right, but broadening the proliferation debate to examine such factors can also strengthen the analysis of proliferation's implications for regional stability.

ARE SMALL ARSENALS BEST?

The consequences of nuclear weapons for other concerns besides stability turn out, on balance, to be negative, from which I conclude that broadening the debate to consider these other impacts strengthens the pessimist case. In contrast, one reviewer of this article suggested that the analysis presented here instead favors a conclusion that small nuclear arsenals are generally best. With small arsenals, states can gain whatever deterrent and stability benefits nuclear weapons provide, while minimizing the negative consequences highlighted above.

This reasoning is faulty. It assumes that all costs are linear, so that costs are small when the arsenal is small and only grow large as weapons deployments increase. Many costs are not linear, however; they are fixed costs that must be paid to acquire an arsenal, regardless of size. For example, the startup costs for building an infrastructure for obtaining fissile materials, turning them into warheads, and producing delivery vehicles are the same no matter how many weapons a state churns out. The same holds true for research and development costs. Similarly, once fissile materials production begins, a risk of catastrophic accident will exist, and some health harm to workers and environmental contamination are almost inevitable. All these costs and risks rise

145. Waheguru Pal Singh Sidhu, "India's Nuclear Use Doctrine," in Lavoy, Sagan, and Wirtz, *Planning the Unthinkable*, 145; Kronstadt, "Nuclear Weapons and Ballistic Missile Proliferation," 5–6; Ahmed, "Security Dilemmas of Nuclear-Armed Pakistan," 790–91.

marginally as more weapons are produced, but they will still be substantial even if only one weapon is ever deployed.

Other consequences are probably independent of arsenal size, or may even be made worse by small arsenals. The psychological impacts are basically existential: they will be present as long as the possibility of nuclear war exists. The stresses on democracy are also probably greatest with small arsenals. Because the survival of a small arsenal depends on keeping secret where weapons have been deployed, the limitations on public debate are likely to be more severe. If a state decides the reasons to seek a nuclear deterrent are overwhelming, the analysis here does provide additional arguments for preferring a small arsenal, but where the case for nuclear acquisition is not this clear-cut, then the various consequences discussed in the latter portion of this article only reinforce the pessimist argument that states are generally better off without nuclear weapons.

If a new state does decide to seek a nuclear capability, the broader focus proposed here is still policy relevant, because it makes clearer what states should do to minimize the negative consequences of a nuclear weapons program. Probably the most valuable step a state could take would be to establish from the outset strong standards for workplace safety and waste disposal, backed up by vigorous oversight and strict accountability. For reasons given above however, it is unlikely that any state will actually do this. If a state believes it is urgent to respond to a security threat and to maintain secrecy, it will exempt a nuclear arms program from any regulations or oversight that might hamper its efforts to achieve a deterrent capability.

Advantages of Recasting the Debate

The assumptions underlying existing policies should never be taken for granted, and academics often perform a useful service when they question conventional wisdom. When Kenneth Waltz and other proliferation optimists challenged the widespread belief that the spread of nuclear weapons should be opposed, they forced nonproliferation advocates to clarify their own theoretical premises and they helped stimulate valuable new empirical research. The result has been an interesting debate with important policy implications. As an attempt to inform policy, however, the optimism-pessimism debate has been both misleading and incomplete.

The debate has focused too much on which side has the better theory according to standard social science superiority tests. Even if the realist and rational choice assumptions that underlie the optimist position make for a more powerful and accurate theory, this would not necessarily mean that nuclear proliferation is advisable. It is also important to evaluate the probability that predictions of stable deterrence might be wrong. For policy purposes, it makes a difference whether there is zero probability or instead a low but realistic risk of a disastrous outcome.

Furthermore, there are good reasons to believe that the possibility of nuclear use cannot realistically be eliminated. I have argued that nuclear weapons are dualistic in nature, meaning nuclear proliferation will involve both potentially stabilizing and potentially destabilizing results. In particular, one can deduce from the very logic of deterrence invoked by optimists certain ways in which nuclear acquisition tends to be provocative rather than caution inducing. Most worrisome, this logic suggests second-strike capabilities may not always be effective. If one side comes to believe that an attack by its adversary is imminent, it may strike first in hopes of achieving damage limitation even if it does not expect 100 percent success.

The cross-cutting implications of nuclear weapons create a trade-off. As a result, there are potential risks in either acquiring or forgoing nuclear weapons, and the very existence of the optimism-pessimism debate proves that different individuals can weigh the trade-offs differently. Given that an evaluation of trade-offs is necessarily involved, it makes sense to consider other possible costs and benefits of nuclear weapons programs that might alter one's assessment of which policy is preferable.

To date, however, the debate has been surprisingly narrow, focusing almost exclusively on stability. Yet, nuclear weapons programs have economic, environmental, and broader political costs and benefits that are also relevant to determining whether proliferation is desirable. On balance, the consequences in these other areas are negative, and although no one cost is likely to rival the harm done by a nuclear or major conventional war, cumulatively these costs can be quite significant. The environmental consequences are probably the most serious: the possible accidents and contamination associated with nuclear weapons production can lead to thousands of premature deaths.

The clarifications and extensions of the proliferation debate introduced in this article show that the pessimist case is really stronger than the way it has been formulated in some recent presentations. They do not necessarily justify a conclusion that nuclear proliferation is never advisable, however: depending on a state's security situation and the other alternatives available, nuclear acquisition may in a small number of cases still appear attractive. Such cases, however, will not be the general rule, meaning efforts to promote nonproliferation still have a valid role. The analysis here leads to two policy recommendations for making such efforts more effective. First, creating greater awareness of the other costs and risks of proliferation may help dissuade some potential proliferators. If people in a state considering the nuclear option think that nuclear weapons are cheap and deterrence is fail-safe, or do not know that nuclear arms programs cause harm even if the weapons are never used in war, the information in this article can be used to disabuse them of such illusions.

Efforts at education and persuasion, however, are unlikely to be effective in all cases. If a country feels insecure enough, it may find the potential benefits of nuclear deterrence too attractive to be convinced not to go nuclear by exhortation alone. Such countries will need to see some alternative way to meet their security concerns. Thus, if the United States and the international community want to promote nonproliferation, they will have either to assist non-nuclear-weapon states in meeting their security needs or to help them identify feasible alternative ways to achieve the benefits they associate with nuclear weapons.

Proliferation optimists have identified some persuasive logic and evidence for believing that nuclear weapons can contribute to security and stability, but their analysis becomes misleading if it suggests that these are the only consequences of nuclear weapons or that regional rivals can never find an alternative path to stability. With nuclear weapons, a state cannot get the good without the bad: a more stable deterrent balance might result, but there will also certainly be some harm to the state's population even if there is no war, and some small but non-zero risk of nuclear war will be created. People must ultimately weigh the pros and cons for themselves, but in doing so they should consider information about all of the consequences of nuclear acquisition, including the many hidden costs that have so far received almost no attention in the proliferation debate.