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NO SUCH THING AS A FREE LUNCH
A Nuclear-User-Pays Model of International Security

Lyndon Burford

The funding of international nuclear risk mitigation is ad hoc, voluntary, and unpredictable, offering no transparent explanation of who is financially responsible for the task or why. Among many non-nuclear-armed states, this exacerbates a sense of injustice surrounding what they see as a discriminatory nuclear regime. The resulting erosion of the regime's legitimacy undermines support for efforts to prevent nuclear weapons dissemination and terrorism. This article proposes a transparent, equitable "nuclear-user-pays" system as a logical means of reversing this trend. This system envisions states contributing financially to international efforts to mitigate nuclear risks at a level relative to the degree of nuclear risks created by each state. "National nuclear risk factors" would be calculated by tabulating the risks associated with each state's civilian and military nuclear activities, as well as advanced dual-use and nuclear-capable missile activities, multiplying the severity of each risk by the probability of it occurring, and combining these results. A nuclear-user-pays model would create financial incentives for national and corporate nuclear risk mitigation, boost legitimacy and support for nuclear control efforts among non-nuclear-armed states, assist in preventing nuclear weapons dissemination and terrorism, and advance nuclear disarmament by helping progressively devalue nuclear weapons.

KEYWORDS: Nuclear risk mitigation; nuclear disarmament; nuclear nonproliferation; nuclear security; nuclear safety

Non-nuclear-armed states often express a sense of injustice at the inequities of international nuclear politics.[1] Analysts generally attribute this to three factors: the unequal rights and obligations arising from the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the perception that nuclear-armed states are not pursuing their disarmament obligations in good faith, and the belief that advanced nuclear states have engaged in technological denial to developing nations.[2] The resulting crisis of legitimacy in what many states see as a discriminatory nuclear regime undermines political will for collective efforts to prevent nuclear dissemination and terrorism.[3] A fourth injustice is increasingly exacerbating this crisis of legitimacy, yet has received little attention to date: the lack of a transparent, equitable mechanism for funding international nuclear risk mitigation efforts. Collectively termed here "nuclear control efforts," these are the global regime of treaties, agreements, organizations, and initiatives that aim to safeguard international security by reducing the number and role of nuclear weapons, preventing their dissemination or use, and preventing nuclear accidents or terrorism. At present,

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nuclear control efforts are funded in an ad hoc manner, with little consideration or acknowledgment of the sources of risks that are being mitigated. In this context, non-nuclear and developing states are being asked (or obliged) in what is perceived as an unjust, arbitrary fashion to help fund the mitigation of risks that other countries have created—almost two-thirds of them developed countries.[4] Despite their objections to the various justice issues outlined here, nuclear nations must face the reality that current perceptions of injustice undermine political will for essential nuclear control efforts that require broad, collective support if they are to succeed.

This article proposes a ''nuclear-user-pays'' model as a logical, transparent, and equitable means of addressing deficiencies in the current ill-defined funding system for nuclear control efforts. The user-pays model is based on the premise that a just system would see states take financial responsibility for the mitigation of the nuclear risks they create. Conversely, demanding that all states increase their financial support for nuclear control efforts exacerbates nuclear injustice. It ignores the fact that nuclear risks are created by a minority of countries yet endured by all, while the direct financial and technological benefits of nuclear risk-generating activities accrue only to those engaged in them. A nuclear-user-pays model would apportion financial responsibility for nuclear control efforts based on the degree to which each state created nuclear risks requiring international mitigation.

The user-pays concept is not new. Responsibility for the consequences of one's actions is a core tenet underpinning contemporary neoliberal economic models. Thus, a nuclear-user-pays system simply emphasizes the norm of financial accountability that developed states champion. It has analogues in national and international ''polluter pays'' models and climate change mitigation schemes and in domestic cases such as the ''sin taxes'' that the United States levies on risk-attracting activities like the consumption of alcohol or cigarettes.[5] Nevertheless, applying a user-pays model to nuclear risk mitigation would be highly controversial. It would require a leap forward in international—and corporate—nuclear transparency and accountability and would face complex political and technical questions. For example, how would nuclear risk be assessed, using what criteria, and with what weighting for these criteria? Who would oversee the funds generated, and how would they enforce payment of dues? How would this authority determine expenditure priorities? Finally, how would the system balance the benefits of greater transparency against the risk of publishing dissemination-sensitive information?[6] While such issues present serious challenges, their resolution lies far beyond the scope of this article. The intention here is to identify deficiencies in the current system for funding nuclear control efforts, and to expand the boundaries of thinking about how this system can be made more transparent and equitable, and therefore, more effective. The nuclear-user-pays model does exactly that.

The Nuclear Problem

Nuclear activities create inherent security risks. Threats arising from military nuclear activities include, among other things, the further dissemination or use of nuclear

weapons—including limited or full-scale nuclear war, whether accidental, miscalculated, or intentional—and nuclear or radiological accidents or terrorism, which in extreme cases may lead to nuclear war.[7] In the civilian sector, the 1986 Chernobyl and 2011 Fukushima disasters demonstrated that severe nuclear accidents might also threaten international security. Today, nuclear risks are increasing due to a range of factors: the threat of further nuclear dissemination, the development of a nuclear arms race in South Asia, the growth of dual-use industries and strategic trade flows, and the potential horizontal and vertical expansion of nuclear energy programs. The nature of these risks transcends national borders. As a result, nuclear risks cannot be addressed effectively by a single powerful state, or even a coalition of committed states. The weakest link in the chain undermines the security of all countries, so maintaining international security requires all countries to support nuclear control efforts.

In this context, international society faces a challenging question: who should pay for nuclear control efforts? Is it fair to expect non-nuclear states (particularly developing ones), facing the potentially catastrophic effects of other nations' nuclear activities, to help pay for the mitigation of risks they did not create? From a justice perspective, this is acceptable on a voluntary basis; contributions to the Group of Eight Global Partnership and the International Atomic Energy Agency (IAEA) Nuclear Security Fund are good examples. However, non-nuclear states are increasingly being expected—or obliged—to pay for the mitigation of nuclear risks. UN Security Council Resolution 1540, for example, obliges states to take ''appropriate effective'' measures to prevent nuclear (and chemical and biological) dissemination and terrorism. The significant variation in support for and implementation of Resolution 1540 demonstrates both a lack of capacity and political will for its implementation among many developing nations and a broader resentment of what is seen as an arbitrary, ''one size fits all'' approach to international security.[8]

Proponents of nuclear deterrence argue that nuclear weapons maintain international peace and stability, thereby generating global benefits. The strategic and risk-related aspects of this argument are addressed further below. From a justice perspective, a key failing of such nuclear optimism is that it ignores that some nations may disagree entirely. During the Cold War, New Zealand Prime Minister David Lange argued, ''To compel an ally to accept nuclear weapons against the wishes of that ally is to take the moral position of totalitarianism, which allows for no self-determination, and which is exactly the evil that we are supposed to be fighting against.''[9] Similarly, to oblige any nation that eschews nuclear weapons and energy to pay to mitigate the catastrophic risks they cause is neither just nor equitable and is therefore likely to be politically counterproductive.

Nevertheless, Stanford University political scientist Scott D. Sagan adopts a similar logic in calling for universal funding increases to the IAEA, arguing that since all states benefit from nuclear non-dissemination efforts, all should pay more to support them.[10] He objects to a proposal for states to ''pay more into the IAEA Safeguards budget in proportion to the number and kinds of facilities they have on their soil that are subject to inspection.''[11] A justice-based critique of this proposal would highlight that it ignores the dissemination risks arising from military nuclear programs. Sagan's objection, however, is that the proposal ''places the financial burden only on the state that benefits from the

nuclear power plant or fuel facility in question and ignores that the nonproliferation benefits of the safeguards are shared by all states.''[12] It is certainly true that all states benefit from nuclear non-dissemination efforts and that IAEA safeguards are an essential aspect of these. However, when viewed through a justice lens, Sagan's argument neglects several crucial points. First, as noted above, nuclear risks are created by few states yet endured by all—while the direct benefits arising from risk-generating activities are enjoyed only by those engaged in them. Why, then, should all states pay to mitigate the risks? Second, different states produce different levels of nuclear risk. Therefore, taxing them arbitrarily (or at least, without reference to a transparent, equitable model), reinforces nuclear injustice, undermining the legitimacy of, and support for, nuclear control efforts. Third, the widespread perception that nuclear-armed states are not pursuing their disarmament obligations in good faith has long been a key factor underlying many other states' reluctance to support greater nuclear security and non-dissemination efforts. This perception may have shifted slightly in response to President Barack Obama's recent pursuit of a more balanced disarmament and non-dissemination agenda.[13] Nevertheless, any such progress is offset by extensive nuclear weapons modernization and upgrade programs that are under way in all nuclear-armed states.[14] In this context, to add further responsibilities, financial or otherwise, to the non-dissemination obligations that non-nuclear and non-nuclear-armed states already face exacerbates the strong sense of injustice surrounding the nature and implementation of the ''disarmament for non-dissemination'' NPT bargain. The response to Sagan from former Sri Lankan diplomat and UN undersecretary general for disarmament affairs Jayantha Dhanapala was telling in these regards: ''An inherently discriminatory treaty cannot be strengthened by further discrimination.''[15]

An additional injustice entrenched in the nuclear disarmament and non-dissemination regime is the lack of a mechanism to ensure that corporations take financial responsibility for the mitigation of the transnational nuclear risks they create. Capitalism presumes that those who take the risks should reap the rewards. What credible capitalist can argue that those who reap the rewards should not bear financial responsibility for the associated risks? A double inequity is apparent here. First, the profits that private nuclear operators accrue are often supported by significant taxpayer subsidies or loan guarantees.[16] Second, having profited from public support, corporations often deflect financial responsibility for mitigating the risks inherent in their operations back on to the state, and therefore, its citizens. A nuclear-user-pays system would provide states with material incentives to legislate for the financial responsibility of corporations in helping to mitigate the nuclear risks they create.[17]

Toward a Nuclear-User-Pays System

An equitable funding system for nuclear control efforts must account for and distinguish between ''primary'' and ''secondary'' nuclear risks on one hand, and ''tertiary'' security risks on the other. Primary risks are defined as those that relate directly to nuclear activities, whether civilian or military. This includes, at a minimum, the size, type, and deployment

status of states' nuclear arsenals; fissile material production infrastructure and stockpiles; the prominence of nuclear weapons in national security strategies; the operation or export of energy-producing and research reactors; fuel cycle activities and/or trade, including mining, milling, conversion, enrichment, fuel fabrication, and reprocessing; and nuclear isotope production and/or trade.[18] "Secondary" nuclear risks are those arising from significant engagement in advanced dual-use or nuclear-capable missile activities.[19] "Tertiary" security risks are defined as those created by factors such as weak legal and regulatory frameworks or border security, which can increase the likelihood of a country being exploited by non-state actors seeking to smuggle nuclear weapons or materials. From a justice perspective, it is necessary to distinguish this type of risk from those arising from primary and secondary sources because the existence of the key problem relates to the latter two. Arms Control Association analyst Peter Crail, for example, calls states presenting tertiary risks "transit states" and notes they pose a risk "particularly if the measures to prevent the acquisition of relevant materials fail in primary origin states."[20] The simple fact is that there would be no nuclear risk to mitigate, and therefore no increased tertiary security costs to states, if not for states' nuclear activities.

The first step toward creating a nuclear-user-pays system would be to assemble a Nuclear Risk Advisory Board (NRAB), most likely under the auspices of the United Nations. This would be a broadly representative group of civilian and military nuclear, international security, and risk-analysis experts from both nuclear and non-nuclear states. The NRAB would first create an exhaustive list of each state's civilian and military nuclear, advanced dual-use, and nuclear-capable missile activities and facilities.[21] It would then assess the type of risk associated with each activity and determine the resulting "nuclear risk indicator" by multiplying the severity of each risk by the probability of it occurring.[22] Calculations of risk probability would take into account existing physical, technical, and human safety and security features, as well as the strength of national border security and trade management systems, depending on the case.[23] Each country's overall nuclear risk indicator would be calculated by combining the risk indicators associated with all its primary and secondary nuclear risk activities. By adding together the risk indicators of all countries, then dividing each country's indicator by this total, the portion of all nuclear-related international security risks that a country generated—its "national nuclear risk factor"—would be calculated. This would determine how to equitably spread financial responsibility for international nuclear control efforts; that is to say, relative to the degree to which each state created risks requiring mitigation. The principles governing contributions from developing countries to the UN regular budget could also be considered here.

In terms of funding disarmament, a nuclear-user-pays model—supported by the precedent embedded in the Chemical Weapons Convention—would see nuclear-armed states and their allies financing the dismantlement, and international verification of dismantlement, of their nuclear arsenals and associated facilities.[24] As noted previously, this does not preclude voluntary contributions. The Model Nuclear Weapons Convention, for example, "provides for the establishment of a voluntary fund to assist States who might otherwise be unable to fulfill their disarmament obligations."[25]

Defining Nuclear Risks

As noted above, the calculation of nuclear risk levels will be highly controversial. Nuclear optimists argue that nuclear deterrence maintains international peace and security, providing benefits to all states. An extrapolation of this argument would suggest that nuclear deterrence policies should result in nuclear-armed states incurring reduced financial responsibilities under a user-pays system for nuclear risk mitigation. In fact, closer examination of relevant factors would suggest the opposite, for several reasons.

First, in the post-9/11 world, there is more contention than ever as to whether nuclear weapons are net producers of security. For example, many former "Cold Warriors" have renounced nuclear weapons in light of changes in the global risk landscape.[26] The issue of nuclear terrorism is key here; many analysts believe this to be the most likely contemporary source of nuclear weapons use.[27] Some also see it as a potential trigger mechanism for full-scale nuclear war.[28] Second, many analysts argue that the maintenance of nuclear weapons is among the key drivers of nuclear dissemination, while the vast majority of international relations scholars and practitioners agree that dissemination reduces international security.[29] Thus, nuclear deterrence, which features prominently in justifications for maintenance of these weapons, again attracts a high nuclear risk factor. A point of contention, of course, is the argument that extended nuclear deterrence helps dissuade US allies from developing nuclear weapons. Leaving aside a possible empirical objection to this point, it is difficult to argue that extended deterrence has similarly dissuaded North Korea or Iran.[30] A third reason that nuclear deterrence creates a high nuclear risk factor is that nuclear threats suffer from a lack of credibility.[31] This results, among other things, from a lack of demonstrated willingness since 1945 to carry out nuclear threats and from the fact that there can be no presumption of such willingness, since carrying out nuclear threats would be highly irrational in the absence of a strong assumption that escalation could be prevented.[32] Even key nuclear optimists such as international relations theorist Kenneth Waltz do not claim that nuclear deterrence eliminates the risk of major war, but rather that this risk "approaches zero" under nuclear deterrence.[33] It is worth remembering that nuclear deterrence has failed to deter conventional attacks on two occasions: the 1973 Yom Kippur War and the 1982 Falklands War.[34]

Other rationalist assumptions also lead to a high nuclear risk factor being attributed to nuclear deterrence. Brookings Institution foreign policy analyst Michael O'Hanlon points out that because realists see great power conflict as unavoidable and nuclear disarmament as impossible, realist premises reinforce the conclusion that given sufficient time, nuclear war becomes almost inevitable under a nuclear deterrence regime.[35] Indeed, probability modeling demonstrates that unless the risk of nuclear war reduces at a constant rate, it does eventually become inevitable.[36] While not denying this specific point, international relations scholar and former Department of Defense official Joseph Nye argues that a failure of nuclear deterrence does not necessarily entail "the apocalyptic conclusions that are often drawn from it."[37] He also critiques probability-based analyses for assuming constant probabilities (as in the repeated-toss-of-a-coin analogy), independence of events, and a static political environment.[38] Stanford University professor emeritus (engineering)

Martin Hellman has demonstrated that it is possible to avoid these pitfalls, and is calling for the US government to conduct rigorous risk-analyses of nuclear deterrence failure.[39] Precedents for work of this nature exist in recent quantitative risk analyses of nuclear proliferation and nuclear terrorism.[40] Similarly, Los Alamos and Lawrence Livermore National Laboratories have conducted risk analyses for various portions of the US nuclear program.[41] Hellman notes that while such estimates are difficult because they might depend on calculating probabilities of events that have never occurred, they are made possible through the use of fault or event ''trees.'' In this approach, ''the failure rates of small events (e.g., the failure of a cooling pump or a backup system) and conditional probabilities are combined to produce an overall failure rate for the much rarer catastrophic event that results when a critical subset of those partial failures occurs.''[42] Ultimately, regardless of disagreements about the likelihood of deterrence failure, it is relatively uncontroversial to say that even a partial failure of deterrence leading to a ''limited'' nuclear war would have a devastating impact on human, ecological and economic systems around the world.[43] Therefore, in the context of the nuclear-user-pays model proposed here, the severity of the risk associated with nuclear deterrence, even if multiplied by a relatively low probability, will necessarily result in a very high nuclear risk factor.

Benefits of a Nuclear-User-Pays System

A nuclear-user-pays framework would have a range of political and international security benefits. First, NRAB deliberations would serve as a springboard for more comprehensive consideration of the complex challenges facing humanity as it pursues the elimination of nuclear weapons and seeks to mitigate the risks associated with a potential ''nuclear renaissance.'' Second, a robust assessment of the risks of nuclear weapons dissemination and use associated with nuclear deterrence failure would help to progressively devalue nuclear weapons. Third, the transparent, responsive nature of NRAB proposals means they would enjoy broader legitimacy and support than current arbitrary funding approaches to nuclear control efforts. Fourth, a user-pays system would introduce a new norm to the nuclear regime: financial accountability. This is already a robust norm in developed countries; linking this widely held norm with nuclear non-dissemination and disarmament will only strengthen the latter.[44] Additionally, requiring developed nuclear nations to practice the financial accountability they preach would help create a perception of equity and justice in the nuclear control regime. Fifth, user-pays accountability would give states material incentives to legislate for the financial responsibility of nuclear corporations in the mitigation of nuclear risks, resulting in more stringent nuclear control efforts from the nuclear industry. Finally, under a nuclear-user-pays system, nuclear states would have increased financial incentives to adopt higher national standards of nuclear disarmament, non-dissemination, security, and safety. The resulting improvements in trade and border security would produce benefits in other areas of international concern, such as preventing, detecting, and dealing with transnational crime.

Possible Critiques of a Nuclear-User-Pays System

It is possible to imagine a scenario in which the NRAB, based on agreed user-pays parameters, concludes that nuclear-armed states, which currently fund the bulk of international nuclear control efforts, actually pay more than their fair share in this regard. Critics might argue that this would lead to resentment and reduced political will within nuclear-armed states for the funding of nuclear control efforts. In fact, this hypothetical scenario reinforces the value of a user-pays model, as it would provide nuclear-armed states with empirical evidence to justify and legitimize their demands for increased financial contributions from other nuclear states.

One of the more challenging technical aspects facing negotiation of a nuclear-user-pays system is the complex, interdependent relationship between nuclear and climate-based risks. Nuclear proponents argue that expanded use of nuclear energy can reduce carbon emissions and thus help to mitigate anthropogenic climate change. However, as physicists Robert Socolow and Alexander Glaser point out, to make a meaningful contribution in this regard, nuclear energy use would need to expand at such a rate that, absent significant progress in disarmament and multilateralization of the nuclear fuel cycle *within the next decade,* the resultant nuclear risks would far outweigh the concomitant climatic benefits.[45] Focusing on the economic factors constraining such rapid nuclear expansion, disarmament expert Trevor Findlay and researcher Justin Alger arrive at a similar conclusion: ''Without major policy shifts in the immediate future nuclear energy's impact on carbon mitigation ... will not just be minimal, it will be virtually unnoticeable.''[46] At any rate, models for comparing climate-related and nuclear risks already exist and could be applied by the NRAB in its deliberations.[47]

Conclusion

The challenge of funding essential nuclear control efforts demands creative, game-changing solutions that break with past patterns of entrenched nuclear injustice and bolster political will for cooperation among all nations. A nuclear-user-pays system offers a logical, equitable means of paying for efforts to mitigate transnational nuclear risks. This system would transparently apportion financial responsibility for nuclear control efforts to states relative to the degree of nuclear-related risk each state generates. In doing so, it would create incentives for nuclear states to legislate for the responsibility of private nuclear entities in helping to finance nuclear control efforts. This nuanced, responsive model of nuclear risk mitigation would boost the legitimacy of nuclear control efforts among non-nuclear nations and create incentives among nuclear nations for the advancement of nuclear disarmament, non-dissemination, security, and safety.

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NOTES

1. Harald Müller, ''Between Power and Justice: Current Problems and Perspectives of the NPT Regime,'' *Strategic Analysis* 34 (March 2010), pp. 189–201. In the present article, the terms ''nuclear-armed state/non-nuclear-armed state'' replace the more common ''nuclear weapon state/non-nuclear weapon state,'' since using the former pair implicitly acknowledges the role and responsibility of all states with nuclear weapons (as well as all NPT members) in advancing nuclear disarmament and non-dissemination. The term ''nuclear state'' is defined here as a state with any civilian or military nuclear, advanced dual-use, or nuclear-capable missile activities. In contrast, ''non-nuclear state'' is defined as a country with no such activities. In the context of a nuclear-user-pays system this is important, as the distinction between nuclear states and non-nuclear states becomes as relevant as that between nuclear-armed and non-nuclear-armed states.
2. This perception has been exacerbated in recent years by attempts to redefine the ''inalienable right'' of all NPT member states to the civilian use of nuclear energy, so as to preclude the right to uranium enrichment or reprocessing. Henry D. Sokolski, ''Towards an NPT-Restrained World that Makes Economic Sense,'' *International Affairs* 83 (May 2007), pp. 537–41.
3. Following Benoît Pelopidas, the terms ''dissemination'' and ''non-dissemination'' are used here in place of ''proliferation'' and ''nonproliferation.'' Pelopidas points out that proliferation connotes ''a fundamentally non-political approach that does not take into account the possibility of change over time in the role and appeal of nuclear weapons.'' It therefore reinforces a set of unhelpful assumptions that are unsubstantiated by the historical record and which limit policy innovation. Benoît Pelopidas, ''The Oracles of Proliferation: How Experts Maintain a Biased Historical Reading that Limits Policy Innovation,'' *Nonproliferation Review* 18 (March 2011), p. 309.
4. Of the thirty countries currently operating electricity-generating nuclear reactors, thirteen represent ''emerging and developing economies,'' a categorization of the International Monetary Fund that includes Russia—clearly a problematic classification when referring to nuclear technology. ''World Nuclear Power Reactors & Uranium Requirements,'' World Nuclear Association, September 13, 2011; ''World Economic Outlook April 2011: Tensions from the Two-Speed Recovery: Unemployment, Commodities, and Capital Flows,'' International Monetary Fund, April 2011, pp. 185–88.
5. Similarly, a tax on the international arms trade has been suggested, with proponents arguing this would increase the price of arms, thus reducing arms transfers, freeing up funds for economic development, and reducing the destructiveness of military conflicts. Michael Brzoska, ''Taxation of the Global Arms Trade? An Overview of the Issues,'' *Kyklos* 57 (May 2004), pp. 149–72.
6. For real-world examples of these and other challenges, see Matthew Bunn, ''Reducing the Greatest Risks of Nuclear Theft and Terrorism,'' *Daedalus* 138 (Fall 2009), pp. 115–16.
7. Even in the United States—a self-proclaimed ''responsible'' nuclear power—the military nuclear sector has experienced accidents and security breaches with alarming regularity. Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, NJ: Princeton University Press, 1993).
8. On capacity and political will, see Togzhan Kassenova, ''1540 in Practice: Challenges and Opportunities for Southeast Asia,'' Stanley Foundation, May, 2011, pp. 1–2. On ''one size fits all'' approach, see Tanya Ogilvie-White, ''Facilitating Implementation of Resolution 1540 in South-East Asia and the South Pacific,'' in Lawrence Scheinman, ed., *Implementing Resolution 1540: The Role of Regional Organizations* (Geneva: UN Institute for Disarmament Research, 2008), p. 44. For discussion of a range of related issues, see Peter Crail, ''Implementing UN Security Council Resolution 1540: A Risk-Based Approach,'' *Nonproliferation Review* 13 (July 2006), pp. 356–59.
9. David Lange, ''Nuclear Weapons Are Morally Indefensible,'' paper presented at the Oxford Union Debate, Oxford, March 1, 1985, <publicaddress.net/great-new-zealand-argument/nuclear-weapons-are-morally-indefensible/>.
10. Scott D. Sagan, ''Shared Responsibilities for Nuclear Disarmament,'' *Daedalus* 138 (Fall 2009), p. 161.
11. Ibid., p. 161.
12. Ibid.
13. Jayantha Dhanapala, ''Evaluating the 2010 NPT Review Conference,'' United States Institute of Peace, October, 2010, pp. 3–4.
14. Ian Kearns, ''Beyond the United Kingdom: Trends in the Other Nuclear Armed States,'' British American Security Information Council, November, 2011, p. 2.

15. Jayantha Dhanapala, ''Common Responsibilities in the NPT—Shared or Asymmetrical?'' in Scott D. Sagan, ed., *Shared Responsibilities for Nuclear Disarmament: A Global Debate* (Cambridge, MA: American Academy of Arts and Sciences, 2010), p. 22.
16. Doug Koplow, ''Nuclear Power: Still Not Viable without Subsidies,'' (Cambridge, MA: Union of Concerned Scientists, February, 2011).
17. Joshua Masters, ''Nuclear Proliferation: the Role and Regulation of Corporations,'' *Nonproliferation Review* 16 (November 2009), pp. 347–61; Sagan, ''Shared Responsibilities.'' Precedents for this exist in the US Nuclear Waste Fund and the Swedish tax levied on the production of nuclear energy. Regardless of the domestic political controversy surrounding the former, the existence of these taxes affirms the nascent norm of corporate financial accountability for nuclear risk mitigation.
18. While the secrecy surrounding military nuclear programs limits the accuracy with which it is possible to assess some such factors, an expert panel should be able to produce credible estimates through ''combined all-source analysis.'' Bunn, ''Reducing the Greatest Risks,'' p. 115. Moreover, while suspicions of covert nuclear militarization complicate this task, the dual-use nature of enrichment and reprocessing technologies means that suspect countries' financial responsibility for nuclear control efforts would still be captured, at least in part, under a nuclear-user-pays system. Due to the practical difficulty of identifying and assessing all radioactive sources worldwide, however, it may be necessary to exclude from consideration the end use of atomic isotopes.
19. What constitutes a ''significant'' level of activity in these fields is a technical and political issue that, like other such questions, lies outside the scope of this article.
20. Crail, ''Implementing UN Security Council Resolution 1540,'' p. 364.
21. The Nuclear Threat Initiative has done this for nuclear materials, as well as assessing other relevant metrics that may contribute to or hinder the development of nuclear materials security. ''NTI Nuclear Materials Security Index: Building a Framework for Assurance, Accountability, and Action,'' Nuclear Threat Initiative/Economist Intelligence Unit, 2012. Similarly, see ''The Model Nuclear Inventory: Accountability is Democracy, Transparency is Security,'' Reaching Critical Will, Women's International League for Peace and Freedom, 2005.
22. Preliminary work on assessing the type of risk associated with each activity has already been done. See Trevor Findlay and Justin Alger, ''G8 Global Partnership Expansion and Extension: A Report for the Department of Foreign Affairs and Trade,'' Canadian Centre for Treaty Compliance, March 31, 2010. On determining a nuclear risk indicator, Martin Hellman explains, ''The danger associated with nuclear deterrence depends on both the cost of a failure and the failure rate.'' Martin E. Hellman, ''Risk Analysis of Nuclear Deterrence,'' *The Bent of Tau Beta Pi* (Spring 2008), p. 15.
23. On the complexities of assessing security value-added by such factors in different national contexts, see Bunn, ''Reducing the Greatest Risks,'' p. 114.
24. Chemical Weapons Convention, April 29, 1997, Article IV, paras. 1, 6, and 16; Article V, paras. 1, 8, and 19; Verification Annex.
25. Merav Datan, Felicity Hill, Jürgen Scheffran, and Alyn Ware, *Securing our Survival (SOS): The Case for a Nuclear Weapons Convention* (Cambridge, MA: International Physicians for the Prevention of Nuclear War, 2007), p. 150.
26. Henry Kissinger, Sam Nunn, William Perry, and George Shultz, ''A World Free of Nuclear Weapons,'' *Wall Street Journal*, January 4, 2007, p. A15. In addition to the vigorous public diplomacy of Kissinger et al., similar pro-zero opinion pieces from equally high-ranking, often conservative, political and military figures have also appeared in Australia, Germany, Italy, Poland, and the United Kingdom, to name but a few.
27. Richard G. Lugar, ''The Lugar Survey on Proliferation Threats and Responses,'' Office of Senator Lugar, June 2005, p. 15, <lugar.senate.gov/nunnlugar/pdf/NPSurvey.pdf>.
28. Hellman, ''Risk Analysis of Nuclear Deterrence,'' p. 15.
29. ''Weapons of Terror: Freeing the World of Nuclear, Biological and Chemical Weapons,'' Weapons of Mass Destruction Commission, 2006, p. 17; ''Report of the Canberra Commission on the Elimination of Nuclear Weapons,'' Australian Ministry of Foreign Affairs and Trade, August 1996, p. 7. Admittedly, determining why states develop nuclear weapons is enormously complex. For comprehensive recent analyses, see: Jacques E.C. Hymans, ''The Study of Nuclear Proliferation and Nonproliferation: Toward a New Consensus?,'' in William C. Potter and Gaukhar Mukhatzhanova, eds., *Forecasting Nuclear Proliferation in the 21st Century: The Role of Theory, Volume 1* (Stanford, CA: Stanford University Press,

2010), pp. 13–37; Scott D. Sagan, "The Causes of Nuclear Weapons Proliferation," *Annual Review of Political Science* 14 (June 2011), pp. 225–44.

30. On a possible empirical objection, see the case of Japan in Maria Rost Rublee, *Nonproliferation Norms: Why States Choose Nuclear Restraint* (Athens, GA: University of Georgia Press, 2009), p. 98. On North Korea and Iran, see Tom Sauer, *Nuclear Inertia: US Nuclear Weapons Policy after the Cold War* (London; New York: I.B. Tauris, 2005), p. 163.
31. Robert Green, *Security without Nuclear Deterrence* (Christchurch, NZ: Astron Media and the Disarmament & Security Centre, 2010), pp. 92–94.
32. Steven P. Lee, *Morality, Prudence and Nuclear Weapons* (Cambridge: Cambridge University Press, 1993), pp. 126–28. For further discussion of why nuclear weapons have not been used in war since 1945, see T.V. Paul, *The Tradition of the Non-Use of Nuclear Weapons* (Stanford, CA: Stanford University Press, 2009); Nina Tannenwald, *The Nuclear Taboo: The United States and the Non-Use of Nuclear Weapons since 1945* (Cambridge: Cambridge University Press, 2007).
33. Kenneth N. Waltz, "Nuclear Myths and Political Realities," *American Political Science Review* 84 (September 1990), p. 740.
34. Ken Berry, Patricia Lewis, Benoît Pelopidas, Nikolai Sokov, and Ward Wilson, "Delegitimizing Nuclear Weapons: Examining the Validity of Nuclear Deterrence," James Martin Center for Nonproliferation Studies, May 2010, pp. 26–27.
35. Michael E. O'Hanlon, *A Skeptic's Case for Nuclear Disarmament* (Washington, DC: Brookings Institution Press, 2010), p. 8.
36. Rudolf Avenhaus, John Fichtner, Steven J. Brams, and D. Marc Kilgour, "The Probability of Nuclear War," *Journal of Peace Research* 26 (February 1989), pp. 91–99.
37. Joseph S. Nye, *Nuclear Ethics* (New York: The Free Press, 1986), p. 120.
38. Ibid., pp. 65–66.
39. Martin E. Hellman, "How Risky is Nuclear Optimism?," *Bulletin of the Atomic Scientists*, March 2011, pp. 47–56.
40. On nuclear proliferation, see David J. Caswell, Ronald A. Howard, and M. Elisabeth Paté-Cornell, "Analysis of National Strategies to Counter a Country's Nuclear Weapons Program," *Decision Analysis* 8 (March 2011), pp. 30–45. On nuclear terrorism, see Matthew Bunn, "Guardians at the Gates of Hell: Estimating the Risk of Nuclear Theft and Terrorism—and Identifying the Highest-Priority Risks of Nuclear Theft," PhD diss., MIT, 2007.
41. Hellman, "How Risky is Nuclear Optimism?" p. 51.
42. Hellman, "Risk Analysis of Nuclear Deterrence," p. 14.
43. See, for example, the latest modeling of the climatic effects of a "regional scale" nuclear war between India and Pakistan, in Owen B Toon, Alan Robock, Richard P. Turco, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov, "Nuclear War: Consequences of Regional-Scale Nuclear Conflicts," *Atmospheric Chemistry and Physics Discussions* 6 (2006), pp. 11745–816; Ira Helfand, "Nuclear Famine: A Billion People at Risk—Global Impacts of Limited Nuclear War on Agriculture, Food Supplies, and Human Nutrition," International Physicians for the Prevention of Nuclear War/Physicians for Social Responsiblity, April 24, 2012, <www.psr.org/nuclear-weapons/nuclear-famine.html>.
44. On the effectiveness of linking norms, see Rublee, *Nonproliferation Norms,* pp. 44–49.
45. Robert H. Socolow and Alexander Glaser, "Balancing Risks: Nuclear Energy & Climate Change," *Daedalus* 138 (Fall 2009), pp. 31–44.
46. Trevor Findlay and Justin Alger, "Nuclear Energy and Climate Change: Our Planetary Savior?" *ISN Insights*, International Relations and Security Network, August 4, 2010, <www.isn.ethz.ch/isn/Current-Affairs/Security-Watch-Archive/Detail/?lng=en&ots627=fce62fe0-528d-4884-9cdf-283c282cf0b2&id=123247>.
47. Felix Chr. Matthes, "Nuclear Energy and Climate Change," Heinrich Böll Foundation, 2005; Socolow and Glaser, "Balancing Risks."