Spring 2019

The Messy Nuclear Landscape: Using Fuzzy Cognitive Mapping to Explore Plausible Nuclear Disarmament Scenarios

Ryan M. Nixon
Old Dominion University, nixonryanm@gmail.com

THE MESSY NUCLEAR LANDSCAPE:

USING FUZZY COGNITIVE MAPPING TO EXPLORE PLAUSIBLE NUCLEAR DISARMAMENT SCENARIOS

by

Ryan M. Nixon
B.A. May 2012, Old Dominion University
M.A. May 2014, Old Dominion University

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

INTERNATIONAL STUDIES

OLD DOMINION UNIVERSITY
May 2019

Approved by:

Jesse Richman (Director)

Regina Karp (Member)

Patrick Hester (Member)

ABSTRACT

THE MESSY NUCLEAR LANDSCAPE:
USING FUZZY COGNITIVE MAPPING TO EXPLORE PLAUSIBLE NUCLEAR DISARMAMENT SCENARIOS

Ryan M. Nixon
Old Dominion University, 2019
Director: Dr. Jesse Richman

Nuclear weapons are seemingly permanent fixtures in international relations. Although nuclear abolitionists and actors within the Nonproliferation Treaty (NPT) and the International Atomic Energy Agency (IAEA) have taken significant steps towards designing a world without nuclear weapons, the longstanding realist logic that suggests nuclear disarmament is nonviable has born more fruit. On the other hand, some proponents of realism have suggested global nuclear disarmament is feasible, given that certain international instabilities are stabilized and that special care is taken during diplomatic negotiations. This presents an opportunity to test these predictions using fuzzy cognitive mapping, a computational modeling technique that identifies problems, their stakeholders, and stakeholders' components in order to determine scenarios that solve complex disputes in ways that benefit the system as a whole. This study identifies two problems regarding nuclear disarmament. First, nuclear weapon states are resistant to giving up nuclear weapons, despite agreements to disarm. This problem follows realist logic. Second, the role that the IAEA plays in safeguarding special nuclear materials while guaranteeing states' rights to nuclear technology is contrasted by states' interest in maintaining levels of secrecy. These two problems constitute a "mess" that this study analyzes. Synthesis between the problems requires that solving one does not make the other worse. Therefore, this study tests various scenarios and finds that, given present-day international instabilities are stabilized, nuclear disarmament is feasible if three conditions are met: First, a global

disarmament agreement must not unreasonably affect states' sovereign rights outside of the agreement. Second, states outlying the NPT must be brought into the negotiations. Finally, present states with nuclear arsenals adopt the IAEA's Comprehensive Safeguards Agreement with the Additional Protocol as a measure of good faith. A final factor suggests states' rights to the technology inevitably means states should have an ability to re-proliferate in the event of future international instability that threatens global security. Once these steps are taken and technological rights guaranteed, this model suggests global nuclear disarmament is possible.

This thesis is dedicated to Tonesia Starchia.

ACKNOWLEDGMENTS

I would like to thank first of all my dissertation supervisor, Dr. Jesse Richman, who was instrumental in helping me develop my model and work through its underlying issues and resultant findings. I would also like to thank my committee, Dr. Regina Karp, who served as the initial inspiration for this study and who pushed me to fully consider as much of the study's problems as possible; and Dr. Patrick Hester (UNC Asheville), who graciously shared with me the modeling knowledge used here as well as his own tools for conducting this type of research.

I would also like to thank all the nuclear scientists and policy experts who spoke with me and helped me at Brookhaven National Laboratory during summer 2018. Particularly, my mentor, Katherine Bachner, the Nonproliferation Policy and Implementation Group Leader, and Susan Pepper, the Chair of the Nonproliferation and National Security Department. Their guidance and knowledge strongly lent to the completion of this study.

Finally, I would like to thank all my colleagues and friends who offered ears, kind words, and even kinder criticisms to help me finish this study.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

Figure Page

Figure Page

CHAPTER 1

INTRODUCTION

1.1 Mess Articulation

Problems do not exist in vacuums. Solving one problem might exacerbate one or more related problems, despite our best intentions. Industrial and technological modernization comes to mind. While modernization leads to increased life quality and expectancy, it displaces indigenous species, pollutes waterways, and contributes to rising global temperatures. The short-term benefits of industrialization and modernization outweigh the short-term costs, but the overall costs might prove too costly for future societies. The balance between industrialization and environmentalism is highly contentious, and many stakeholders are firmly and squarely on one extreme end or the other. Solving these problems requires, in a non-dictatorial world, something more holistic than simple political debate in legislatures and democratic elections. While useful, these institutions have thus far proven incapable of solving the problem. The various stakeholders, each with independent influence, can slow or stop problem resolution. Therefore, it might be more feasible to approach problems at this magnitude with a methodology that attempts to satisfy, or at least satisfice, all relevant stakeholders.[1]

As in the climate change debate, in international politics the question of nuclear weapons presents a problem that has thus far avoided synthesis. Stakeholders have for decades attempted to resolve the problem, or to at least soften the edges.

---

[1] Obviously, on the other hand, it is impossible to satisfy or satisfice all ~7.7 billion humans and countless states, multinational corporations, non-governmental organizations, and others. Attempts should be made to satisfy or satisfice the most stakeholders as possible.

The nuclear disarmament movement has been around since almost immediately after the 1945 atomic bombings of Japan. The normative argument is one of morality. Nuclear weapons shrink a total war into a few short hours while maintaining total war's pain,[2] which, according to the abolitionist, is an unacceptable capability for any state to possess. Furthermore, they argue, nuclear weapons pose the risk of accidental detonation or the proliferation through theft or sale to non-state actors that cannot be deterred by conventional means. These moral arguments stem from knowledge of the direct consequences of nuclear attack, including immediate and delayed fatalities, in addition to unintended consequences dozens of miles away, such as the Daigo Fukuryū Maru (F/V Lucky Dragon 5) incident in which a Japanese fishing vessel was irradiated during the Castle Bravo thermonuclear test in 1954. To the disarmament movement, it is often a question of good versus evil.

To nuclear weapons states, the question is one of survival. To survive the "Thucydides Trap,"[3] nuclear weapons are necessary because they erase incentives for a military power to attack a rising power. The US cannot survive a nuclear war with China; therefore, if and when China overtakes the US as a global or regional hegemon, the simple fact that both states have nuclear weapons with second-strike capabilities that can survive a first strike means the transition in the balance of power will not delve into total war. Nuclear weapons states argue, therefore, that nuclear weapons are necessary to preserve the precarious international stability and prevent a major war. As will be discussed in Chapter 5, many thinkers and actors take this argument to a seemingly extreme conclusion—nuclear weapons should be horizontally spread to states that are likely to be good stewards of nuclear technologies. Indeed, Kenneth Waltz argues

---

[2] Adapted from Thomas C. Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966), 21.

[3] This term was coined in Graham T. Allison, *Destined for War: Can America and China Escape Thucydides's Trap?* Kindle edition (New York: Houghton Mifflin Harcourt, 2017).

nuclear weapons would bolster peace in the Middle East if Iran had a nuclear deterrent to counter Israel's nuclear deterrent.[4] To nuclear weapons states, therefore, the question is not Biblical; it is not about good versus evil, but it is certainly about preventing Armageddon. At the very least, it is about preventing World War III.

But the nuclear weapons problem is not merely a battle between disarmament activists and nuclear weapons states. There are roughly 200 recognized states, and fewer than ten of them have nuclear weapons, and the majority of those that do not possess nuclear weapons make up a considerable UN voting bloc, the Non-Aligned Movement. There are weapons systems production firms within nuclear weapons states. There are international verification and compliance agencies, such as the International Atomic Energy Agency. Religious leaders and the media, while not necessarily particularly powerful to solve the problem, certainly have some noticeable level of influence over the faithful and the curious. Finally, Outlier States must be acknowledged. How does the Democratic People's Republic of Korea (North Korea) or the Islamic Republic of Pakistan fit into the problem? Can synthesis be reached in a way that can get these states onboard with the rest of the international community in the event that a global disarmament treaty is negotiated?

And the nuclear weapons problem is not limited to a single problem. On the one hand, as already acknowledged, there is, quite simply, a disagreement over whether or not states *should* have nuclear weapons. This is a normative argument about how the world *ought-to-be*. On the other hand, solving this problem by simply banning nuclear weapons would require significant verification, and many, if not all, former nuclear weapons states would likely resist inspections that are too invasive, calling them violations of sovereignty that are unnecessary. Nuclear

---

[4] Kenneth N. Waltz, "Why Iran Should Get the Bomb: Nuclear Balancing Would Mean Stability," *Foreign Affairs* 91, no. 4 (2012): 2-5.

weapons states would, therefore, likely abandon international arrangements that allow the International Atomic Energy Agency to perform inspections that are too comprehensive.[5] Therefore, in addition to the morality-versus-survival problem, there exists a problem of governance. Is it possible to negotiate a path towards nuclear disarmament while simultaneously guaranteeing former nuclear weapons states do not feel trapped and do not feel like their sovereign rights have taken a backseat to the new world order? This becomes even more complicated when we attempt to bring in the Outlier States mentioned above. These two problems, when taken together and acknowledging that solving one might make the other worse, constitute what I refer to in the rest of this text as the "mess."

Before modeling can even attempt to solve these problems and the constitutive "mess," I must offer a major acknowledgment. The international environment, at the time of writing, is far too complex to solve the problem right away. I make no claims to have found an immediate and simple (or even difficult) solution to the "mess" or the problems. There are at present several "messes" that need to be solved prior to any attempts to reach an international consensus on the nuclear weapons problem. These are discussed in Chapter 8 and include the problems in Eastern Europe, particularly Ukraine and Georgia; the problems with the South China Sea and other disputed maritime shipping lanes; the Kashmir dispute between India and Pakistan; and three lesser but important disputes. These include the Middle East problem, the question of Taiwan, and the dispute on the Korean Peninsula. It is unlikely synthesis between stakeholders can be reached until these problems and "messes" are addressed, and solving all of those problems and

[5] For example, presently there is debate about how to safeguard Brazil's planned nuclear submarine, which falls under a military exemption. Future safeguards arrangements that un-exempt secret military systems are likely to fail to reach agreement.

"messes" at once is far outside the scope of this research, which is focused solely on the nuclear weapons problem.

This acknowledgment is not novel in the disarmament literature. O'Hanlon has explicitly acknowledged this reality of international affairs. These contentious issues, he writes, make disarmament improbable, but solving them, he adds, makes resultant war in a disarmed world implausible.[6] In other words, solving the nuclear "mess" in a world devoid of the aforementioned international disputes, and avoiding creating new disputes, avoids the risk of World War III or a "Thucydides Trap." Therefore, modeling in this research takes place under the assumption that O'Hanlon's imagined world is possible and then asks the question, "Is global nuclear disarmament possible?"

Finally, given that these international problems are resolved and given that the model is a good representation of the problems, I hypothesize that three of the "mess'" variables can be altered so that nuclear weapons can be removed from the system without making either of the problems worse. First, sovereignty must remain a staple in international affairs. No former nuclear weapon state should be forced to endure reductions to its sovereignty outside of what presently is agreed upon through existing treaties. Second, a future disarmament treaty must affect only the disarmament process and be potentially temporary, depending on the security needs of independent states. In other words, the treaty cannot be "too big." Third, it is important that Outlier States be given more international recognition. States like the Democratic People's Republic of Korea should be not only brought into the disarmament negotiations but should be given more representation on other international platforms. This does not mean increasing their prestige so far that they are more important than the permanent members of the UN Security

---

[6] Michael E. O'Hanlon, *A Skeptic's Case for Nuclear Disarmament*, Kindle edition (Washington, D.C.: Brookings Institution Press, 2010), Kindle location 985.

Council, for example; rather they should be given slightly more prestige than non-nuclear states. A final consideration is that the only known mechanism for stabilizing security in a disarmed world is to accept the ability to re-proliferated in short order.

1.2 Study Approach

Nuclear weapons pose a prisoners' dilemma. The possible strategies include cooperating (disarming) and defecting (not disarming). The payoffs for mutual cooperation might be better than mutual defection, which does not preclude the possibility of nuclear war,[7] but the cost imposed on me if I disarm while the other side defects is a powerful reason to accept mutual defection. The possibility of nuclear war through mutual capability is better than being caught unprepared for a nuclear war. Evolutionary biologist Richard Dawkins calls the cost imposed on a unilateral cooperator the "sucker's pay-off."[8] In a dyadic relationship between belligerent or potentially belligerent states, the "sucker's pay-off" in the nuclear world might be to receive nuclear attacks while lacking the capability to retaliate, as Japan suffered during WWII.

But this does not mean that mutual disarmament is impossible. Indeed, the above prisoners' dilemma assumes two sides only get one shot at either cooperating or defecting. This compels "egoistic" behavior because defecting is always a dominant strategy to cooperating in single-round matches. But Robert Axelrod notes that international relations occurs on a continuous timeline. States have the expectations of running into one another again in the future. Mutual defection breaks down as the dominant strategy if the game is played on an indefinite

[7] See Chapter 2 for a discussion about the costs of nuclear war.
[8] Richard Dawkins, *The Selfish Gene: 40th Anniversary Edition* (Oxford: Oxford University Press, 2016). Kindle edition: 263.

timeline.[9] I can apply Axelrod to the nuclear weapons problem and suggest that there is a time horizon where nuclear cooperation becomes possible, if only because "egoistic" impulses drive states towards mutual cooperation and a better payoff. Work has already been done in this field. Russett[10] and Brams[11] demonstrate that Axelrod's iterated prisoners' dilemma can be applied to arms control and nuclear weapons. McGinnis, on the other hand, notes that cooperative relationships in arms control are weak and tend to break down as players seek to include or resolve other issues.[12]

This demonstrates the need for an alternate model with specific assumptions about state goals. These include several key issues that are expanded upon throughout the body of this study. These include 1) assumptions about security, 2) assumptions about confidence in the status quo and worlds we are capable of achieving, 3) assumptions about the role nuclear weapons and developments subsequent to their creation play in either transforming or maintaining international politics, and 4) assumptions about state goals, specifically assumptions about what it takes to convince states to buy in to global disarmament.

First, this study relies heavily on an assumption that is explicitly built into the model. That is, the human knowledge of nuclear fission and fusion is a permanent fixture. Therefore, there is an inherent ability that, even in a world without nuclear weapons, nuclear proliferation is *always* within the realm of possibility, be it horizontal or vertical proliferation. Therefore, a major assumption this study makes is that embracing, rather than trying to smother, this re-

---

[9] Robert Axelrod, *The Evolution of Cooperation: Revised Edition* (New York, New York: Basic Books, 2006). Kindle edition: 10

[10] Bruce M. Russett, *The Prisoners of Insecurity: Nuclear Deterrence, the Arms Race, and Arms Control* (San Francisco: W.H. Freeman, 1983).

[11] Steven J. Brams, *Superpower Games: Applying Game Theory to Superpower Conflict* (New Haven: Yale University Press, 1985).

[12] Michael D. McGinnis, "Issue Linkage and the Evolution of International Cooperation," *Journal of Conflict Resolution* 30, no. 1 (1986): 141.

proliferation capability can maintain security. In a disarmed world states can threaten rapid proliferation to deter other actors from nuclear, or even non-nuclear, transgressions. This creates a binary set of options from which states can choose in reference to disarmament. Either we can enjoy security with *nuclear deterrence* or we can enjoy security with *the threat of nuclear deterrence*. One of these options carries an inherent threat of nuclear war, while the other requires an extra step before the inherent threat is achieved. Scott Sagan believes the ability to rapidly reconstitute nuclear forces creates intense instability and will likely result in nuclear war because the first side to build a warhead will believe it can win the war through first use.[13] On the other hand, as demonstrated in Chapter 2, it will also consider how a first use or first strike will affect the global environment and politics. Furthermore, Schell argues the attacked will likely retaliate against the attacker, even if not immediately. This changes the potential attacker's calculus and maintains mutual deterrence even when one side reconstitutes its nuclear capability first.[14] In other words, short-order re-proliferation capability (defined later as rearmament within a matter of weeks) does not destabilize the system or increase the likelihood of nuclear or conventional war if a realist critique is adopted. This *requires* a realist understanding of what is at stake when designing a disarmament treaty. If we are willing to try to live in a world without immediate nuclear deterrence, getting the treaty right demands we weigh the costs and benefits.

Therefore, second and similarly, as is explained by the arms control, disarmament, and other literature on international politics woven through this study, I make key assumptions about confidence. With the two options states possess, which offers more confidence regarding our

---

[13] Scott D. Sagan, "Shared Responsibilities for Nuclear Disarmament," *Daedalus 138*, no. 4 (2009): 158.
[14] Jonathan Schell, "The Abolition," reprinted in *The Fate of the Earth, and The Abolition*, (Stanford, CA: Stanford University Press, 2000), 161.

security needs? Schell argues our confidence is increased with "weaponless deterrence,"[15] especially if one considers our imperfect confidence that *nuclear* deterrence can hold. This position is held to various degrees of confidence by Perkovich and Acton,[16] Schelling,[17] Wheeler and Booth,[18] and O'Hanlon.[19] I too follow this line of reasoning (in Chapter 8 I illustrate this fully through an extended form game). That is, adopting a realist critique that assumes states are cost-benefit calculators, confidence is increased without nuclear weapons and with re-proliferation capability maintained by the former nuclear weapons states. This confidence boosts security considerations in the first assumption.

Third, the question remains as to whether or not nuclear weapons have transformed international politics. Are nuclear weapons the best source of security by eliminating the uncertainty of your adversaries' capabilities? Recall Kenneth N. Waltz's confidence above and belief that Iran should have nuclear weapons. If yes—if nuclear weapons have transformed the system by eliminating the threat of major war—then there is no reason to continue this conversation. But history has not played out in the Waltzian way. Horizontal proliferation has not born fruit, and, defying normative claims about who *should* have nuclear weapons, major events have unfolded that bolster arms control, if not disarmament. For example, the Joint Comprehensive Plan of Action (the "Iran Nuclear Deal") demonstrates that even Iran does not necessarily agree with Waltz. It is also unlikely that they have eliminated the threat of major war. The 2019 India-Pakistan crisis demonstrates that even nuclear-armed states are willing to risk

---

[15] Schell, 158.
[16] George Perkovich and James Acton, *Abolishing Nuclear Weapons*, Adelphi Paper 396 (London: Routledge for The International Institute for Strategic Studies, 2008).
[17] Thomas Schelling, "A World without Nuclear Weapons?" *Daedalus* 138, no. 4 (2009): 126.
[18] Ken Booth and Nicholas J. Wheeler, "Beyond nuclearism," in *Security Without Nuclear Weapons: Different Perspectives on Non-Nuclear Security*, ed. Regina Cowen Karp (New York: Oxford University Press, 1992).
[19] O'Hanlon, Kindle location 937.

escalation, even if realist logic suggests both nuclear-armed states will ultimately back down.[20] Ultimately, when two nuclear-armed states at the brink back down, determining which cause and effect is true (the threat of escalation or diplomatic success) is as difficult as proving a negative.

Furthermore, the question of the International Atomic Energy Agency (IAEA) persists. To what extent has or should the IAEA transform international politics? If the IAEA is too empowered, nuclear weapons states might not sign onto a future disarmament treaty. Therefore, states must empower the IAEA, rather than eliminating nuclear sovereignty. Baroness Shirley Williams disagrees, writing that, "What we really need now is the additional protocol that enables the IAEA to simply walk into any place it fears might possibly be involved in the development of nuclear weapons—a laboratory, factory or anywhere else—without giving any advance notice before it conducts inspections."[21] The IAEA's 1997 Additional Protocol does outline various scenarios that give inspectors sweeping authority to inspect anywhere they please if they have reasonable suspicion that clandestine activities can take place in certain locations, but adoption of the Additional Protocol is not compulsory, and there are time restrictions. Baroness Williams' prescription for solving the nuclear weapons problem is near perfect in that it greatly diminishes the risk of clandestine operations, but it is far-from-perfect in that it requires states to adopt it. If a state seeks to clandestinely develop a nuclear weapons program, it will likely circumvent Williams' IAEA.

On the other hand it is obvious that some level of state-driven IAEA empowerment is warranted if disarmament talks are to be successful. Cheating is a major concern in a disarmed or disarming world. It would be reasonable for a disarming Russia to expect the US will hide away

---

[20] Kenneth N. Waltz, "The Spread of Nuclear Weapons: More May Better," *Adelphi Papers*, 171 (London: International Institute for Strategic Studies, 1981), 7.
[21] Shirley Williams, "Multilateral Nuclear Disarmament," *Political Quarterly* 83, no. 2 (2012): 340.

half a dozen bombs before the inspectors arrive, and therefore, Russia has incentives to hide away half a dozen (or maybe half a dozen plus one) before inspectors arrive. Dealing with potential cheaters requires more than a multilateral approach. There needs to be an IAEA with increased state-driven power in at least some circumstances,[22] but this power is conditional to the specific and immediate needs of the international community of states. The aforementioned re-proliferation capabilities ensure that the IAEA does not take on a life of its own.

Therefore, nuclear weapons have only transformed the international political system insofar as states assume it has. On the other hand this transformation is weak; states can envision a collectivity of empowered inspectors to oversee and manage the knowledge of proliferation.

Finally, fourth, what would it take for states to buy into disarmament? This question raises multiple questions that must be addressed in order to answer. First, how do you dismantle a nuclear warhead? In other words, is the nuclear problem merely technical in nature? The first thing we must do is to acknowledge that the solution requires a political answer because the nuclear weapons problem is not merely a technical problem. We have dismantled nuclear warheads in the past. Getting states to buy into disarmament requires several assumptions, raised by basic additional questions.

Where do we want to be? The first and obvious truth—the realist truth—is that we desire security. More than mere security, we desire stable security. This harkens back to the first and second assumptions. If, for example, rapid re-proliferation capability destabilizes political disputes and increases the likelihood of major war, including nuclear war, then obviously that is

---

[22] This includes increased facility access, accelerated access to information under treaty, acknowledgement that IAEA inspectors are authorities, increased scientific training for inspectors to increase analytical competence, and strengthening incentives for cooperation and disincentives for defection. Jack Boureston and Charles D. Ferguson, "Strengthening Nuclear Safeguards: Special Committee To the Rescue?" *Arms Control Today* 35, no. 10 (2005): 22.

not where we want to be. If, on the other hand, we can disarm without risking war, then we have added more stability (by essentially also eliminating the threat of nuclear war). And if we look at the problem through the security lens, we can separate ourselves from moral prescriptions that presuppose nuclear weapons are bad and disarmament is good. If the referent object is about stable security then we can dispense with arguments about good and evil, and we can focus solely on risk and basic survival. I deviate from Schell, who frames nuclear abolition as a question of the survival of the human species and, by extension, the survival of our loved ones.[23] Stable security, and thus diminished risk and increased survival, is obviously based in selfish bias for personal life over non-life, and if we accept this then we can also accept that human beings (and thus states) will generally bias decisions that promote personal life over non-life. If we accept this then we can answer the question—where do we want to be?—with a discussion about goals.

On the one hand there are nine states possessing nuclear weapons. In this sense nuclear weapons are "possession goals" to enhance national standing in terms of security in an international system governed by anarchy. On the other hand there are other goals states seek that often contradict "possession goals." Arnold Wolfers differentiates "possession goals"—goals that enhance the state's survivability through obtaining something of value—and "milieu" goals, which "aim instead at shaping conditions beyond [the state's] national boundaries."[24] Milieu goals are not necessarily altruistic in nature; states often make certain concessions in international politics because it values the benefit it receives from cooperation in concession

[23] Schell, 4-6.
[24] Arnold Wolfers, *Discord and Collaboration: Essays on International Politics* (Baltimore, Maryland: The John Hopkins Press, 1962), 73-74.

more than the cost of the thing it sacrificed. In other words what we want depends on the benefit we expect to receive from either possessing nuclear weapons or disarming.[25]

What about risk management? Under what conditions do we expect nuclear weapons to either manage or increase risk? Would disarmament be the reverse? Ultimately, answering this question is to help us better fully understand survivability. If nuclear weapons establish order through certainty, then disarming would require massive changes to management in the international system of states. But the world we build to replace nuclear weapons must be recognizable. As previously mentioned, and as will be more fully developed in the ensuing chapters, a New World Order—a single world government—is an unacceptable alternative to stability through nuclear deterrence. Managing risk means we can conceive of disarmament in the world that already exists.

To figure out what we want, we need to understand security with nuclear weapons and security without nuclear weapons. Nuclear weapons contribute to our security in several ways. They do so by changing state options. In a dyadic relationship they deter direct wars by establishing mutual assured destruction (MAD), which reduces our beneficial options to one—back down; they prevent inadvertent war and increase de-escalation in the event of hostile developments; and they establish the threat of death as a major deterrent. Taken together, nuclear weapons increase our security.[26] Additionally, nuclear weapons can help compensate for weak conventional forces. For example, as the US increases its military budget, Russia need not

[25] For more on possession and milieu goals and how this pertains to this study's findings, see the discussion and conclusion chapter.
[26] Regina Cowen Karp, "Introduction," in *Security with Nuclear Weapons? Different Perspectives on National Security*, ed. Regina Cowen Karp (Oxford; New York: Oxford University Press, 1991), 17.

balance conventionally, as it already has achieved nuclear equilibrium.[27] They allow states to resolve disputes through the threat of force, rather than escalating to actual force. They all-but eliminate the threat of attrition warfare, if one follows the conclusions of MAD. They allow non-nuclear states to enjoy security guarantees from major powers under "nuclear umbrellas," which frees up smaller states' resources so they can be spent on building international prestige in non-military ways. And finally, nuclear weapons create the hierarchical system and, therefore, they create a recognizable and stable order.[28]

On the other hand, nuclear weapons pose enormous risk—and thus insecurity—in several ways. Addressing these is the other side of the coin we are trying to figure out. First, there exists the unavoidable threat of nuclear accident. While states can do their best to avoid an accident, accidents happen despite our best intentions.[29] The possibility of nuclear terrorism, irrational actors inhereting nuclear arsenals, inadvertant militarized escalation, and regional competition over nuclear potential exasperate insecurity. Additionally, nuclear weapons programs are expensive, meaning there is a domestic cost to a nuclear weapons program.[30]

Therefore, how do practitioners manage the nuclear age? Various mechanisms are at play. First, there is a narrative of the nuclear taboo, a longstanding tradition on the non-use of nuclear weapons since World War II.[31] Press, Sagan, and Valentino note that, "If nuclear weapons are seen as taboo, their use might generate revulsion that could lead to deeper restraint

---

[27] Kenneth N. Waltz, "The Emerging Structure of International Politics," *International Security* 18, no. 2 (1993): 51.
[28] Kenneth N. Waltz, "The Stability of a Bipolar World." *Daedalus* 93, no. 3 (1964): 882-884.
[29] O'Hanlon discusses various accidents that could have resulted in nuclear detonation. O'Hanlon, 54-57.
[30] On the other hand, financial costs are rarely, if ever, part of states' calculation to proliferate or not. Anne Harrington De Santana, *Nuclear Weapons as a Currency of Power: Deconstructing the Fetishism of Force* (2010, ProQuest Dissertations and Theses), 54.
[31] Nina Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use," *International Organization* 53, no. 3 (1999): 433.

in the future. If non-use is merely a tradition, however, breaking it could set a new precedent, potentially increasing the likelihood that others will use nuclear weapons in the future."[32] This is a slight diversion from realism, and this assumption acknowledges that determining between these two possible outcomes requires understanding realism, on the one hand, and the process by which ideas are shaped through discourse, or constructivism, on the other hand.

As aforementioned, global practitioners also manage the nuclear age through various arms control agreements. Many of these are identified in Chapters 5 and 6. It should be noted here that, although arms control generally works, with a few hiccups here and there (e.g., the bilateral suspension of the Intermediate-Range Nuclear Forces (INF) Treaty in 2019 between the US and Russia), arms control faces a realist backlash, some calling it an illusion that only exists when there are no insecurities. Colin Gray writes, "the theory and practice of arms control is to security what the flat-earth postulate was to cosmology: sincerely believed, responsive to some empirical evidence (the world can look fairly flat), attractive to common sense, but alas, invalid."[33] In other words, there is a strong possibility that arms control is doomed to failure. That said, arms control is a known mechanism and pathway towards (or at least in the direction of) global zero.

It should also be noted that managers in the nuclear age have, up until this point at least, peacefully ended the Cold War, more or less constructed successful security guarantees to non-nuclear weapons states, developed nuclear weapons free zones, established the IAEA, established the NPT, and conducted countless nuclear security summits, regardless of outcome.

---

[32] Daryl Press, Scott Sagan, and Benjamin Valentino, "Atomic Aversion: Experimental Evidence on Taboos, Traditions, and the Non-Use of Nuclear Weapons," *The American Political Science Review* 107, no. 1 (2013): 189.
[33] Colin S. Gray, *House of Cards Why Arms Control Must Fail* (Ithaca: Cornell University Press, 1992), 2.

On the other hand, as is mentioned in Chapter 2, a peaceful resolution to the Cold War does not necessarily translate into a peaceful resolution to all conflicts that include the possibility of nuclear strike. Security guarantees are not set in stone (as Colin Gray would probably agree). Nuclear weapons free zones do not mean free from fallout or other detrimental global effects of nuclear war, nor are nuclear weapons free zones endowed with the muscle necessary to enforce the law. The IAEA and the NPT cannot prevent nuclear war; they can just make it a little less likely. And nuclear security summits, like the one between Donald Trump and Kim Jong Un in February 2019, are often less-than successful. What this means is that, as is addressed in Chapter 3, managing the nuclear age in the twenty-first century requires a holistic understanding and approach.

Next, to figure out what we want, we must ask two questions: 1) is disarmament desirable? This question stems from many of the questions posed above. And 2) is disarmament feasible? To answer the first question, Schell has previously argued that disarmament is a moral imperative. Other abolitionists identified in Chapter 5 agree. But whether or not disarmament is desirable is not the important question. But because some actors say it is desirable, we can connect this question with feasibility. Wheeler and Booth see this as a necessary connection because disarmament begins with the policymakers who want disarmament. If disarmament is desired by decision makers, then disarmament is not feasible.[34] They additionally posit that disarmament is only possible through a process-oriented gradual reduction. In other words, the idea is to wean states away from nuclear weapons. This weaning requires increasing cooperation. In 2010 Russian and US presidents Medvedev and Obama put this cooperative, process-oriented gradual reduction to use, signing the New START treaty. But, as shown by the bilateral

[34] Wheeler and Booth, 54.

suspension of the INF Treaty in February 2019, this process can be derailed. This study seeks to completely eschew the process. (Or at least, it seeks movement from some non-zero number to zero; whether or not that number is in the thousands or dozens is up to the imaginations of the reader. In the end, this model tests security stability without nuclear weapons.) Under my prescription, states will negotiate the terms of a disarmament treaty, choose a date on a calendar, and then open their doors to the outside world to verify the destruction of warheads, very similar to the INF Treaty warhead dismantlement inspections. This approach is akin to tearing an adhesive bandage off of an old wound in one pull. It is likely to be painful, but the pain will be shorter lived than if drawn out by a gradual process. This requires a small amount of big steps rather than an unknown number of small steps. With this approach there are fewer areas for derailment (although skepicism is magnified, which begs for a demonstration of benefit and reward through, for example, fuzzy cognitive mapping).

Finally, to come full circle, answering what we want requires us to acknowledge the most difficult aspects of a disarmed world, a disarming world, or even a world merely considering its nuclear options. Namely, how is verification of compliance strong enough that uncertainty is manageable? Furthermore, how can the IAEA be strong enough to verify compliance, but not so strong that the state loses its ability to govern itself? As previously mentioned, the IAEA must be empowered by the state. If the IAEA becomes more powerful than the sum of the power granted it by states without mechanisms for rearmament if necessary, it creates incentives for defection from the disarmament (or non-proliferation) regime. This has already been addressed above (see re-proliferation capability). For our purposes here, the IAEA has a first duty to know how many warheads are out there. This complicates the problems in Chapters 5 and 6 and the “mess” in Chapter 7. These numbers are usually closely guarded

secrets, and determining the actual number requires substantial reassurances through transparency. And it requires major baiting of milieu rewards to entice states to be open and truthful.

A couple paragraphs above, I briefly make the case for ripping the bandage off in a single movement—going from some non-zero number to zero all at once. One of the reasons for this is because as nuclear redundancies diminish, numbers matter. Dismantling 1,000 warheads when you have 10,000 is simple. Dismantling 1,000 when you have 1,500 is more difficult. Going from 10 to 5 is even more difficult still. Going from 5 or 10 to zero is not unthinkable, but it is unbelievable. These stages create defection points each round. The *great leap to zero* circumvents the potential political crises that will emerge as new institutions are framed, new conventions are formed, and more potentially doomed-to-fail nuclear summits are held in order to manage the next *small leap to a non-zero number*.

Therefore, to turn Colin Gray's argument on its head and to adopt from John Mueller, the irrelevance of nuclear weapons narrative suggests that if we get to a point where nuclear disarmament is possible, not only will it be likely to occur out of mere circumstance, it will be likely to occur because re-proliferation capability is enough to deter belligerence. The weapons served their purpose in developing MAD. They are now irrelevant.[35] They are unnecessary to maintain MAD explicitly because of the fact that we cannot put the nuclear genie back in the bottle. The question now is whether we should put the nuclear genie out to pasture.

---

[35] John E. Mueller, "The Essential Irrelevance of Nuclear Weapons: Stability in the Postwar World," *International Security* 13, no. 2 (1988): 56

The Model

This study adopts a form of systemic decision-making called Fuzzy Cognitive Mapping, adapted from Axelrod[36] and later Kosko.[37] Fuzzy cognitive maps show relations between concepts as well as the strengths of those relationships. Imagine a hospital with a patient with a communicable disease as well as a doctor and a nurse. If we are examining this social network in terms of each actor's health, the doctor and nurse can positively and strongly increase the patient's health by providing various forms of accepted medicine, and the patient can weakly or moderately decrease the doctor's and the nurse's health by transmitting the disease. As this model stands, the doctor and nurse can neither increase nor decrease the other's health unless the patient first transmits the disease to one or the other. Therefore the fuzzy cognitive map also accounts for changes in time. At timestamp 0, when the patient is admitted, the doctor and nurse's health is unaffected; however, at timestamp 1, after the patient has been in the hospital for a pre-defined time, the doctor and nurse's health could be affected. And at timestamp 2, considering one or the other healthcare worker has caught the disease; the newly infected actor can affect the health of the uninfected actor.

This study incorporates this form of modeling and applies it to the nuclear weapons problems and "mess." Its methodology adapts strongly from Patrick T. Hester and Kevin MacG. Adams[38] to create a highly structured representation of the nuclear problems and the constitutive nuclear "mess." The problems and the "mess" are created on an online modeling platform called Mental Modeler, the quantifiable contents of which are imported into an Excel spreadsheet

---

[36] Robert M. Axelrod, *Structure of Decision: The Cognitive Maps of Political Elites* (Princeton, N.J.: Princeton University Press, 1976).
[37] Bart Kosko, "Fuzzy Cognitive Maps," *International Journal of Man-Machine Studies* 24 (1986): 65-75.
[38] Patrick T. Hester and Kevin MacG. Adams, *Systemic Decision Making: Fundamentals for Addressing Problems and Messes*, 2nd ed. (Springer International, 2017).

containing a macro capable of analyzing the model through a sigmoid transfer function to allow the model to evolve from one timestamp to the next. Finally, the model is examined by asking various "what-if" questions. That is, what happens if we make certain predefined changes to the structure of the "mess"? Do these changes help to solve the problem? Do they make the scenario worse off for relevant stakeholders?

The modeling also takes place in an international environment that accepts the basic tenets of political realism. Hans Morgenthau posits that politics behave according to objective laws of human nature; politics is a response to changes in the measurement of power; the *concept* of power is fluid through time; morality is not insignificant, but it is often in contrast with successful policy; there is no objective *good* or *bad* in the laws of nature; and political realism is *the* domain of politics, despite its explicit acknowledgement that other schools of thought exist and matter to their respective subjects.[39] Morgenthau acknowledges the existence of international law, human rights, and other institutions outside the scope of political realism, but he does not think they matter in the long term. States might temporarily decide to cooperate on a specific issue, but they are bound by the laws of human nature to defect from the cooperative relationship as soon as a reasonable opportunity presents itself. To be fair, as is discussed in Chapter 8, this tenet of political realism does not detract from my argument, but rather it bolsters it. Furthermore, this research deviates from political realism, despite acknowledging it, by acknowledging that other institutions indeed matter, if only in the present. It furthermore adds that states will first accept the laws of human nature, but they *can* also overcome them through rational choice in search of goals beyond their national boundaries that bolster their security but

[39] Hans J. Morgenthau, *Politics among Nations: The Struggle for Power and Peace*, 4th Ed. (New York: Knopf, 1967), 4-11.

not at the expense of others' securities. In this sense, I adopt from Wolfers, E.H. Carr,[40] and Ken Booth,[41] who argue that states can accept the balance of power, but will also work towards a communal view of utopia when possible, if only because it serves a non-selfish benefit to the state moving towards utopia. Booth explicitly calls for going beyond realism to reach a fuller empiricism of the study of international relations.[42]

1.3 Summary of the Study's Findings

The model I construct in Chapters 5 – 7 is highly complex, containing over 50 movable parts (and over 150 ways to move them). Although I go to great lengths to explain how each concept interacts with surrounding concepts, readers without engineering management backgrounds and a strong interest in social mechanics might find the model chapters dry. Therefore, a brief summary of the study's findings is in order, so that the average reader will understand from the beginning what this highly complex machine is working towards.

In short, ripping the nuclear bandage off quickly (the *great leap to zero* approach) is feasible, but this claim comes with several crucial caveats.

First, as demonstrated in late February 2019,[43] several ongoing international disputes can spiral towards crisis, and nuclear deterrence might be the only thing presently restraining nuclear powers.[44] A terroristic suicide car bombing in Kashmir's Pulwama district by a Pakistani militant against India's Central Reserve Police Force spiralled out of control, culminating in Pakistan

---

[40] E.H. Carr, *The Twenty Years' Crisis, 1919-1939* (New York: HarperCollins, 1946).
[41] Ken Booth, "Security in Anarchy: Utopian Realism in Theory and Practice," *International Affairs* 67, no. 3 (1991): 527-545.
[42] Booth, 534.
[43] At the time of writing, this crisis is ongoing. The unfolding of events beyond February 2019 is unknown to the author.
[44] Although the power of diplomacy cannot be discounted.

shooting down two Indian military jets over Pakistan's airspace. India and Pakistan have danced close to the brink of major militarized international dispute before, even after each state constituted nuclear deterrents. The quick recovery by March 1, 2019 and the increased diplomatic urgency surrounding the India-Pakistan 2019 crisis demonstrate two things: 1) Removing India's and Pakistan's nuclear deterrent before resolving the ongoing 71-year-old Kasmir dispute might lead both states to major war to resolve the Kashmir issue. And 2) there is a strong likelihood that diplomatic urgency is fostered by the nuclear deterrent, rather than diplomacy undermining nuclear deterrence. Beyond Kashmir there are a half dozen or so ongoing international geopolitical disputes that require the same treatment. Removing their respective states' nuclear deterrents is untenable without resolving their disputes.

Therefore, moving forward from some unknown date on a calendar when nothing prevents us from trying the *great leap to zero*, there are feasible things we can do that will make disarmament feasible and stable. First, nuclear weapons states need strong reassurance that their natural rights to govern their territory or to move in the international realm are not infringed beyond a pre-negotiated disarmament treaty. This has the effect of limiting international organizations' powers. The IAEA is not empowered beyond the treaty. Second, the states outlying the NPT must be brought into the international fold, economically and diplomatically. Particularly, the recognized nuclear powers should acknowledge North Korea and Pakistan as nuclear powers. This might require an amendment to the NPT, temporarily forgiving past human rights violations, and bringing these states into the Nuclear Suppliers Group. It certainly requires dropping sanctions. Third, the recognized nuclear weapons states and the states outlying the NPT must ceremoniously sign the IAEA's Comprehensive Safeguards Agreement with the Additional Protocol as a measure of good faith. This will activate the IAEA to power commensurate to

agreed upon provisions in the disarmament treaty. A final crucial point highlights the importance of replacing security with MAD with a "weaponless deterrence." Realizing or maintaining the capability to constitute or reconstitute militarized nuclear forces is, according to the model developed in the following chapters, the only way to maintain stable and recognizable security. By working Schell's "weaponless deterrence" into the provisions of a working disarmament treaty, we can empower the IAEA through other provisions enough to deter proliferation through transparency, while limiting the IAEA's power to stop proliferation. This acknowledges Colin Gray's contribution that arms control only works when it can work. This leads to a resultant conclusion that disarmament *will* work only when it *can* work, and the IAEA will have to live with this.

The above scenario is captured using fuzzy cognitive mapping, ascribing to realist claims that the possession of nuclear weapons increases security. My model, however, counters the realist's position that nuclear weapons *best* maximizes the security needs of states. The ability to reconstitute nuclear weapons drives security without nuclear weapons. Furthermore, the fact that no stateholders—not even nuclear weapons states or even North Korea—are ignoring the nuclear weapons problem. Rather, historically they have demonstrated sincere eagerness to work towards resolving this problem. In other words, states recognize and accept that the problem is real and not merely in the imaginations of anti-war activists.

What accounts for this recognition when nuclear weapons are a perfect demonstration of state capability? The model I present leaves us with epistemological uncertainty, due to its highly formalized structure that severs it from meaning. It shows cause and effect but not implication. Arnold Wolfers may offer some insight (expanded in the final chapter). He argues states have possession goals and milieu goals. Possession goals are things sought in competition with other

states. These are egotistical, competetive, and highly political, and they lead to a system of great competition and an inability to think in terms of the whole. They are merely to look inward rather than at the social environment. Milieu goals are actions states take to shape the social environment in which they operate. To a realist the milieu is anarchy, but the milieu is created through the actions and behaviors of states, rather than created by international structure. By shaping the milieu, states shape the choices of others. This is not for altruistic purposes, but rather out of egotistical sociability. That is, socially interacting with the environment serves our foreign policies. It is to serve our self-interests.[45]

If we think about our nuclear choices not merely as a realist would—not merely about how they immediately serve our security needs—we note that alternatives become clearer. Arms control serves no possession goals for nuclear powers, but it serves to shape the social environment in which other actors consider their options. This requires some level of self-restraint and cooperation; it is reasonable to offer self-restraint and cooperation if you expect it from others. But more important, as the prisoners' dilemma can attest, mutual cooperation, while not a dominant strategy or serving to bolster possession goals, self-restraint and cooperation benefits the self-interest of the actor.[46] This study suggests nuclear powers, whether recognized or not, seek both possession goals and milieu goals. Their concern about the role nuclear weapons play in the social context, demonstrated by their engagement in resolving the problems, and the understanding that shaping the social context through self-restraint and increased cooperation is driven by self-interests rather than altruism, explains why the model converges on increased security without nuclear weapons than with.

---

[45] Wolfers, 67-80.
[46] Regina Karp, "Nuclear Disarmament: Should America Lead?" *Political Science Quarterly*127, no. 1 (2012): 57.

1.4 Organization of the Study

This study is in eight chapters.

In Chapter 2 I identify relevant literature regarding arms control, disarmament, mutual assured destruction, and the scientific literature pertaining to the effects of nuclear weapons from climatological, psychological, and sociological perspectives. This chapter makes the case for relevancy as well as the urgency of this study.

In Chapter 3 I discuss the background of the modeling technique, the philosophy of fuzzy cognitive mapping, and the theoretical reasoning behind the study. Of particular note, this chapter addresses eight error types in logic that should be avoided during various stages in the modeling (problem structuring, action, and observation). While this study strives to avoid all error types, it is of particular importance that it avoids modeling the wrong problem (the Type III error) and solving one problem while making another problem worse (the Type IV error). The chapter goes on to discuss how problems interact and create a "mess," which is a problem made up of other problems and is larger than the sum of its constituent problems. The chapter therefore, adopting from Hester and Adams, discusses why this study is more than merely trying to solve a single problem.

Chapter 4 lays out the methodological framework, fuzzy cognitive mapping, as well as the problem structuring proposed by Hester and Adams. The chapter shows how this study seeks to model abstractions of the nuclear weapons problems and "mess" within an abstraction of the real-world system. It furthermore discusses the specifics of the model, including its rationale behind using the sigmoid transfer function (as opposed to a bivalent or trivalent function) as well as using a Likert-type scale (as opposed to a truly continuous scale). The chapter also provides easy-to-follow simulation examples.

Chapter 5 attempts to model Problem 1, which states that nuclear-armed states are resistant to disarmament, while significant portions of the world desire a nuclear-free international system. In doing so it first articulates the problem, providing a background discussion on disarmament, deterrence, and arms control, as well as political realism. It then methodologically goes through six problem parameters (who, what, why, where, how, and when) including qualitative reasoning for each quantitative link between model components. It finally tests the model's stability by running a hypothetical test. In this case, it gives the International Atomic Energy Agency the preponderance of power to solve the problem. Doing so, however, would commit the Type IV error by taking the decision away from nuclear weapons states. In this scenario, nuclear weapon states would likely drop out of safeguards agreements and demonstrate that international governance is less feasible than initially thought.

Chapter 6 attempts to model Problem 2, which states that there is a disagreement as to how much international governance is necessary to ensure verification of online, peaceful nuclear programs. It articulates the problem with a discussion on nuclear safeguards and the theoretical background that makes safeguards agreements possible. It repeats the previous chapter's who, what, why, where, how, and when structure, providing link justification. It finally performs a stability test by ensuring nuclear weapons states' sovereignty is not affected and that nuclear security is initially maximized. This solution, too, exposes a Type IV error because Outlier States are strongly opposed and therefore unlikely to disarm and are unlikely to agree to future disarmament treaties unless they have a seat at the table.

Therefore, Chapter 7 stacks Problem 1 and Problem 2 on top of each other and restructures the "mess" to account for the role nuclear weapons play between the problems, providing link update justifications. It then runs six scenarios to test whether or not nuclear

weapons can be removed from the system. It finds that nations can disarm given that certain steps are taken. First, there can be no lasting reduction in nuclear weapons states' sovereignty. Second, a disarmament treaty must be limited in its scope and contain a clause for withdrawal. Third, Outlier States must be engaged. When all three steps are taken, states can begin the process of disarmament.

Chapter 8 begins by acknowledging the possible Type IV error. That is, we cannot be certain that we can avoid World War III in a disarmed world. At the very least we cannot be certain we can avoid war between the US and China if each state loses its deterrent capability. Therefore, it acknowledges that the present time is not the right time to negotiate to disarmament. There are certain international realities that must be dealt with before we can avoid the Type IV error. It then discusses how the ability for former nuclear weapons states to re-proliferate might maintain stability in a disarmed world through two ways. First, re-proliferation will cause states in conflict to de-escalate to avoid suffering a nuclear war. Second, the threat of proliferation can be used to solve conflicts because the cost of proliferation is high if one wants to achieve a mutual assured destruction between states. The chapter finally addresses remaining uncertainties. First, Outlier States cannot be certain they will be rewarded for cooperation. History has shown that sometimes former rogue states are punished, despite giving up their nuclear programs. Getting them to trust the major powers will be difficult. Second, it cannot be certain that negotiations towards disarmament will be in good faith. The DPRK, for example, might try to misrepresent its preferences in order to get a better—or avoid the worst—outcome. Lastly, this study addresses and acknowledges variation in outcome by using different simulation types and attempts to overcome this limitation. Lastly, Chapter 9 summarizes the study and its findings, offering a discussion about the study's implications and the future of nuclear weapons.

CHAPTER 2

SIGNIFICANCE OF THE STUDY

2.1 The Costs of Nuclear Conflict

Previously the threat of a limited nuclear war, where both sides limit the number of nuclear warheads used during conflict,[47] was thought to most likely occur between India and Pakistan.[48] In 2017 there was heightened reason to suspect the United States and North Korea as potential candidates due in large part to escalating tensions brought about by the 2017 Korean Crisis. This chapter sets the stage for the challenges modeled and analyzes in the rest of the study by examining in detail the literature on nuclear deterrence and its limitations.

The probability of deterrence breaking down between the US and North Korea was arguably not zero in 2017, and the costs of a nuclear war are sufficiently high to warrant a serious discussion about the future utility of nuclear arsenals. This chapter demonstrates that nuclear deterrence can break down in at least four non-mutually exclusive ways. First, two players suffer from mutual uncertainty. If each side believes it will suffer a first strike, each has incentive to preempt nuclear war by attacking first. Second, either side might suffer from threat incredulity. If either side believes the deterrent threat made by the other is unbelievable it can therefore believe the costs of a second strike are tolerable. Third, conventional wars between nuclear powers can escalate to nuclear war if either side believes losing is synonymous with dying. Finally, either side can suffer a nuclear terrorist attack. While the probability of nuclear

---

[47] Jeff A. Larsen and James M. Smith, *Historical Dictionary of Arms Control and Disarmament* (Maryland: Scarecrow Press, Inc. 2005), 128.

[48] For example, see Alan Robock and Owen Brian Toon, "Local Nuclear War, Global Suffering," *Scientific American* 302, no. 1 (2010): 74-81 and Adam J. Liska, Tyler R. White, Eric R. Holley, and Robert J. Oglesby, "Nuclear Weapons in a Changing Climate: Probability, Increasing Risks, and Perception," *Environment* 59 no. 4 (2017): 25.

terrorism is low, if an incident occurred there is no return address for retaliation, leaving the attacked state few options outside retaliating against the state suspected of giving rise to the nuclear terrorist. Furthermore, it is possible a nuclear terrorist attack can resemble an attack by a nuclear regime.

The effects of a nuclear war between the US and North Korea (or any other two nuclear-armed states) would be catastrophic, affecting the global climate, severely stressing societies, and pushing individuals to their psychological breaking points. This literature review suggests the effects of these consequences would likely compel a serious discussion about the future of deterrence and thus nuclear weapons. On the other hand, if the bulk of the scientific literature estimates intolerable global consequences following a limited or total nuclear war, then it is reasonable to suggest disarmament talks can be taken seriously now, rather than following catastrophe. The evidence presented through the literature provides states and societies the means by which to have a serious discussion about disarmament. While this project in no way predicts the outcome of that discussion, it does show that serious discussion can be achieved without suffering through costly nuclear wars.

2.2 Korean and US Limited Nuclear War

In 2007 George Shultz, William Perry, Henry Kissinger and Sam Nunn reinvigorated the disarmament conversation because deterrence does not apply to accidental or unauthorized nuclear weapons use or miscalculation.[49] They explicitly allow for the possibility of nuclear war between the US and North Korea and between nuclear states in general. Particularly as new proliferation occurs, the system can become less stable. The Donald Trump Administration and

[49] George P. Shultz, William J. Perry, Henry A. Kissinger Sam Nunn, "A World Free of Nuclear Weapons," *Wall Street Journal* (New York, N.Y.), January 04, 2007.

Kim Jong Un during the Korean Crisis (2017 – present) appeared to be heightening nuclear tensions and diminishing deterrence stability, forming what could have become a limited nuclear war. For the purpose of this analysis it is assumed any nuclear war between these regimes will be limited due to North Korea's finite stockpile and capabilities, relative to the US.

As of 2014 the United States has roughly 4,650 nuclear weapons either stockpiled or deployed in addition to another 2,700 weapons awaiting dismantlement.[50] This includes land-based intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and strategic warheads that can be loaded onto heavy bombers. US warhead yields range from the 10 ton "Davy Crocket" device to the 15-MT Castle Bravo. Estimates as of July 2017 suggest North Korea has zero deployed nuclear warheads. It is uncertain how many non-deployed, stockpiled weapons North Korea currently possesses;[51] however, US estimates suggest North Korea has as many as 60 warheads.[52] NORSTAR seismic testing estimates North Korea's largest nuclear test on September 3, 2017 produced a yield of approximately 250-KT.[53]

Due to the US's reliance on proportionate response—a guarantee of a second strike retaliation proportionate to the opposing side's first strike—and the current lack of evidence of North Korean weapons larger than 250-KT, this analysis does not believe a limited nuclear war

---

[50] Hans M. Kristensen and Robert S. Norris, "US Nuclear Forces, 2014," *Bulletin of the Atomic Scientists* 70, no. 1 (2014): 86.
[51] Hans M. Kristensen and Robert S. Norris, "Status of World Nuclear Forces," *Federation of American Scientists*, July 8, 2007, https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.
[52] Joby Warrick, Ellen Nakashima, and Anna Fifield, "North Korea now making missile-ready nuclear weapons, U.S. analysts say," *The Washington Post*, August 8, 2017, https://www.washingtonpost.com/world/national-security/north-korea-now-making-missile-ready-nuclear-weapons-us-analysts-say/2017/08/08/e14b882a-7b6b-11e7-9d08-b79f191668ed_story.html?utm_term=.8d46b85aaab2.
[53] "The nuclear explosion in North Korea on 3 September 2017: A revised magnitude assessment," *NORSTAR*, September 12, 2017, https://www.norsar.no/press/latest-press-release/archive/the-nuclear-explosion-in-north-korea-on-3-september-2017-a-revised-magnitude-assessment-article1548-984.html.

would necessarily escalate to megaton-sized weapons. However, any limited nuclear war between the US and North Korea would be devastating in terms of human casualties.

Nuclear deterrence along those lines of direct human fatalities has held the peace for decades; however, at least four scenarios show how nuclear war could break out between the two, escalating each side to at least attempt to use weapons with yields upwards of 250-KT: mutual uncertainty, non-credible threats, escalation of conventional warfare, and response to nuclear terrorism.

Mutual Uncertainty

Deterrence can break down if either side believes it will be struck first—what Schelling calls "reciprocal fear of surprise attack."[54] Schelling illustrates this dilemma with an armed burglar and an armed homeowner. If both the burglar and homeowner draw their weapons against each other, then the burglar fears the homeowner will shoot first. The homeowner fears the burglar will shoot first. Because both sides prefer to live, the fear of the burglar shooting first makes it necessary for the homeowner to shoot first, and vice versa. Under anarchy, where no police force can arrest either side for shooting first, constraint cannot be seen as a rational move. Morrow reemphasizes this, adopting from Schelling. His model suggests if either side believes it will be struck first, it has incentive to launch a first strike because the costs of receiving a first strike are greater than the costs of receiving a second strike.[55]

---

[54] Thomas Schelling, *The Strategy of Conflict* (Cambridge, Massachusetts: Harvard University Press, 1980), 217.
[55] James D. Morrow, *Game Theory for Political Scientists* (Princeton, N.J.: Princeton University Press, 1994), 180.

If relations between the United States and North Korea had devolved into a nuclear standoff, Donald Trump may have feared Kim Jong Un was planning to strike first. Kim Jong Un may have also feared Donald Trump was planning a first strike. Because the costs of receiving a first strike are potentially higher than receiving a second strike—given both sides have contingency delivery systems—both sides have incentive to launch a first strike, potentially curtailing the other side's retaliatory capabilities. If North Korea believed the Trump Administration was planning to launch a first strike, North Korea could have launched more attacks against the US if it strikes first.

Non-credible Threats

During the Cold War deterrence provided stability through the concept of mutual assured destruction (MAD). Using nuclear weapons against the other was unthinkable because, due to each side's second-strike capabilities, "the expectation of retaliation would surely constrain his hand."[56] On the other hand, asymmetric capabilities can break down deterrence through a process of major or minor, non-mortal miscalculations that can lead to general or total war, such as threatening the enemy.[57] If one state makes non-credible threats towards the other, each side might find itself over the brink. Morrow notes that a rational first strike could occur if one side believes it can take out the other side's retaliatory capabilities.[58] A first strike can be rational if the opposing side threatens painful retaliation, and the retaliatory threat is be non-credible.

[56] Bernard Brodie, *Strategy in the Missile Age* (Princeton, N.J.: Princeton University Press, 1959), 185.
[57] Schelling (1966), 97-99.
[58] Morrow, 181.

If North Korea's retaliatory threats against the US were non-credible, and if Trump believed he could disarm North Korea by launching a first strike then a first strike becomes more likely. Given available unclassified information, such an attack would likely see warheads launched against about a dozen sites, including known launch pads and fissile material enrichment facilities.[59] Nevertheless, there is circumstantial evidence that North Korea, aware that its launch pads are "JDAM bait," is using its missile launches from aboveground pads to distract attention from a covert silo program.[60] If undetected silos exist then even 15 or so 1-MT weapons might be insufficient to disarm North Korea, allowing for a North Korean second-strike volley. Furthermore, this possibility takes on a familiar and unsettling calculus. If North Korea believed the US was planning a preemptive strike to take out its first strike capabilities, it has incentive to use those capabilities before a US first strike. In other words, mutual uncertainty and non-credible threats accelerates the risk of nuclear war.

Escalation of Conventional Warfare

A minor armed confrontation can escalate to a larger war because it signals that both sides are risk accepting.[61] On the other hand, Kenneth Waltz argues nuclear weapons provide robust stability, writing that when two nuclear powers engage in conventional warfare, each side is likely to draw back and offer concessions out of fear of nuclear escalation.[62] While the formal

---

[59] North Korea has several bases, facilities, research centers, and testing sites. "North Korea Facilities: Missile Map," *Nuclear Threat Initiative*, http://www.nti.org/gmap/missile_north_korea.html.
[60] On the other hand, there is no direct evidence of such a program. Ralph Savelsberg and James Kiessling, "Was North Korea's July 4th Surprise A Mobile Launched ICBM?" *Breaking Defense*, July 21, 2017, https://breakingdefense.com/2017/07/was-north-koreas-july-4th-surprise-a-mobile-launched-icbm/.
[61] Schelling (1966), 104.
[62] Waltz (1981), 5.

logic of this argument is sound, concession does not always offer the highest possible reward. Furthermore, risk accepting behavior can escalate a larger war to nuclear brinkmanship, particularly given that one side has everything to lose by conceding from the conflict. It is possible that a given conventional war is a zero sum war, where at least one side has intense resolve to achieve a specific goal, such as the overthrow of the existing regime. In such a case, if concessions do not increase the probability of survival, but rather bolster the other side's goals, then the potentially willing side becomes unwilling to concede. If the losing side believes death is inevitable by conceding but has a small chance of survival by going nuclear, then using nuclear weapons is the more rational move. To illustrate this consider two states. State A and State B are fighting a conventional war. Both states have nuclear capabilities. State A's unmovable goal is to eliminate State B. State B is losing the war. State B can concede, where death has a probability of 1, or it can launch a nuclear attack against State A, where death has a probability of less than 1. State B's best option is to go nuclear, where the probability of survival is some number greater than zero.

Donald Trump announced during his first prepared address to the United Nations in September 2017, the US has "no choice but to totally destroy North Korea."[63] This statement is likely tailored to leave little room for misinterpretation. While it could be mere rhetoric, it is certainly possible that a minor armed confrontation, such as a Naval and ground-based blockade of North Korea, can escalate to ship-to-ship and cross-border fighting. Given Trump's public position, it is likely such an escalation will serve as a pretext for a larger military campaign. While a conventional war will likely be painful for both sides, the odds of a North Korean

[63] Ali Vitali, "Trump Threatens to 'Totally Destroy' North Korea in First U.N. Speech," *NBC News*, September 21, 2017, https://www.nbcnews.com/news/us-news/trump-un-north-korean-leader-suicide-mission-n802596.

victory are low. Even if Kim considers concession, he will have to weigh that option against the inevitability of a subsequent continued war until he is out of power. The other option is to inflict extraordinary pain on the United States by going nuclear, which provides a small sliver of hope that Kim will survive if Trump takes the realist position and decides Korea is "The wrong war, at the wrong place, at the wrong time, and with the wrong enemy."[64] In this event, the breakdown of deterrence brings up the possibility of mutual uncertainty and non-credible threats incentivizing Trump to go nuclear first.

Terrorism as a Pretext for Deterrence Breakdown

Schultz, et al, identifies the "most alarming" risk of unauthorized use—terrorism. Nunn elaborated in October 2008, arguing, "I'm much more concerned about a terrorist without a return address that cannot be deterred than I am about deliberate war between nuclear powers. You can't deter a group who is willing to commit suicide. We are in a different era. You have to understand the world has changed."[65] On the other hand, the risk of nuclear terrorism is low, while a nuclear conflict between the US and North Korea might be somewhat more likely. Matthew Bunn constructs a mathematical model of the risk of nuclear terrorism. He argues the probability is low. The terrorist group would first need to acquire the bomb by directly stealing a weapon, acquiring one from an insider, purchasing one on the black market, or receiving one from a state. It would then need to transform it into a working bomb (if it receives an unfinished weapon or materials). It would next need to transport the bomb without detection. Finally it

---

[64] This Korean War-era quote is from Omar Bradley, "Military Situation in the Far East" (hearings, 82d Congress, 1st session, part 2, p. 732, May 15, 1951).
[65] Beth Maclin, "A nuclear weapon-free world is possible, Nunn says," *Belfer Center for Science and International Affairs*, October 20, 2008, https://www.belfercenter.org/publication/nuclear-weapon-free-world-possible-nunn-says.

would need to decide to actually use the weapon. Each of these scenarios has some level of probability. When taken together the probability of a terroristic nuclear attack is very low.[66]

On the other hand, low probability events happen often. People win multimillion-dollar lotteries and meteorites impact the earth on a regular basis, despite the odds against any given person winning or any given rock colliding with the earth. In the improbable event that a terrorist organization acquires a nuclear weapon, nuclear terrorism can break down deterrence in two ways.

First, a terrorist organization can proliferate through the willing or unwilling help of a nuclear regime. Nuclear weapons are unlikely to be built by the terror group, leading them to seek to acquire by theft or from inside or outside agents. Given that the group proliferates and detonates the device against the US, it is likely US intelligence agencies will attempt to trace the origins of the weapon back to the country where it was built. If North Korea attempts to sell nuclear materials on the black market, if a rogue North Korean soldier steals a weapon and sells it, or if a criminal agent or group is able to steal materials from unsecure caches and sell them, then the US is likely to punish North Korea, potentially including the use of nuclear retaliation. Because terrorists do not have a return address, and because of the high emotional response to a nuclear terrorist attack, it is likely the US will punish North Korea in some way. Donald Trump might use such an event as pretext to a nuclear attack in hopes of decapitating the North.

Second, nuclear terrorism can break down deterrence because a nuclear terrorist attack might resemble an attack carried out by a nuclear regime. If a terrorist group proliferates and charters a fishing vessel to a US military installation on a small island in the western Pacific Ocean, detonating the weapon would appear suspiciously similar to Kim Jong Un's threat to

---

[66] Matthew Bunn, "A Mathematical Model of the Risk of Nuclear Terrorism," *The Annals of the American Academy of Political and Social Science* 607, no. 1 (2006), 105.

attack Guam during summer 2017. The initial response, prior to intelligence investigation, would likely be to retaliate against the most likely aggressor. If the Trump Administration believes it is under direct nuclear attack by North Korea, it will likely retaliate before the criminal investigation draws its conclusions.

2.3 Effects of a Limited Nuclear War

Alex Wellerstein's "NUKEMAP," hosted by the College of Arts and Letters, Stevens Institute of Technology, allows users to simulate nuclear detonations anywhere on the planet. Using two potential candidate cities for nuclear strikes, a single round volley using 150-KT airburst detonations directed at Pyongyang, North Korea and Honolulu, Hawaii results in an estimated three quarters of a million direct fatalities, with half a million in Pyongyang. Total injured exceeds a million. The ionizing radiation ring for such an explosion is 1.35 km^2, where the fatality rate is estimated at 95%.[67] These numbers do not account for indirect fatalities injuries due to panic-induced mass migration or separation from medical treatment. Further, direct and indirect fatalities during the initial day or so after an attack do not reflect the total impact of nuclear warfare. Climate changes, social pressures, and psychological pressures create a perfect storm of human tragedy likely to significantly outlast the nuclear war.

Climate

Throughout the Cold War, where the concept of nuclear war was total rather than limited, experiments and models gave rise to a secondary, and perhaps more devastating, effect of

[67] This simple analysis holds all other things equal, such as wind speed and direction, burst height, and weapons' properties. Alex Wellerstein, "NUKEMAP," *the College of Arts and Letters, Stevens Institute of Technology*, 2017, http://nuclearsecrecy.com/nukemap/.

nuclear war. The term "Nuclear Winter" entered the popular lexicon to describe the effects of nuclear explosions setting fire to large quantities of organic and inorganic compounds, resulting in millions of tons of black carbon rising to high altitudes and diffusing throughout the stratosphere where it would block significant portions of sunlight from reaching the ground, causing global temperatures to drop to sub-freezing levels, even during the summer months.[68] Following this, vegetation would die off and agriculture would largely come to an end. While the theory was not error-proof,[69] the bulk of research suggests that more robust modeling overcame Nuclear Winter's theoretical uncertainties.[70] Following the Cold War the risks of Nuclear Winter subsided, but some contemporary models suggest even a small nuclear war could have a devastating impact on the climate.[71] While the risk of total nuclear war has decreased following the end of the Cold War, the concept of limited nuclear war gave rise to the term "Nuclear Autumn."

In 2017 Liska, et al, explore the effects of a limited nuclear war on climate change. They find that a limited nuclear war, during which dozens of small to large nuclear warheads are exchanged between two or more states, has the potential to cause significant burning of structures, vegetation, or other organic or polymer-based matter, potentially releasing upwards of 5 million tons of black carbon into the atmosphere. The impacts on the climate would be drastic, with a resultant impact on human survival. First, agricultural growing seasons could be reduced

---

[68] R P Turco, O B Toon, T P Ackerman, J B Pollack, and C. Sagan, "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions," *Science* 222, no. 4630 (1983): 1283-1292.
[69] For example, K. A. Emanuel in 1986 said the concept of nuclear winter "has become notorious for its lack of scientific integrity." See K. A. Emanuel, "Nuclear Winter: Towards a Scientific Exercise," *Nature* 319, no. 6051 (1986): 259.
[70] For a discussion on the various models, see Curt Covey, "Climatic Effects of Nuclear War," *BioScience* 35, no. 9 (1985): 563-69.
[71] Alan Robock, "Nuclear Winter Is a Real and Present Danger," *Nature* 473, no. 7347 (2011): 275-6. For more discussion on Nuclear Winter in the twenty-first century, see Seth D. Baum, "Confronting the Threat of Nuclear Winter," *Futures* 72 (2015): 69-79.

by about a month or a month and a half each year for the next five years. Second, global temperatures could decrease for the next quarter century. Third, there could be an immediate dip in global temperatures to a low not observed in a millennium. Fourth, precipitation brought by Asian monsoons could decrease by 20-80%, which could result in much drier climates in the Americas, Africa, and Australia, causing, what they call, a "global nuclear drought." Finally, the reduction in available food could cause a billion people to die from starvation and increase violence in acutely affected regions as resources become scarcer.[72]

Liska, et al, expand upon a model proposed by Toon, et al, in 2007. Toon argues fires resulting from nuclear explosions in "megacities," or densely populated urban areas, from a nuclear exchange consisting of 100 15-KT weapons could release 1 to 5 million tons of black carbon into the atmosphere. They argue this will cause surface temperatures, rainfall, and the length of agricultural growing seasons to be greatly affected. The result is severely decreased agricultural production and subsequent famines lasting over a decade.[73] Toon's model assumes a large exchange of relatively small (by today's standards) nuclear weapons. Liska, et al, note today's nuclear weapons are usually 6 to 330 times larger than those dropped on Japan and that "The use of only one 5-MT land-based missile deployed by China could burn an area similar in size to that of one hundred 15-KT explosions."[74] In other words, increasing yield and decreasing the number of weapons in a nuclear exchange overcomes Toon's unlikely scenario.

---

[72] Liska, et al, 24.

[73] Owen Toon, Alan Robock, Richard Turco, and Charles Bardeen, "Consequences of Regional-Scale Nuclear Conflicts," *Science* 315, no. 5816 (2007): 1224. [From here on this is referred to as Toon (2007A).] This policy forum paper is a summary of their full model found at Owen B. Toon, Richard P. Turco, Alan Robock, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov, "Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism," *Atmospheric Chemistry and Physics* 7, no. 8 (2007): 1973-2002. [From here on this is referred to as Toon (2007B).]

[74] Liska, et, at, 26.

The models predicting the effects of nuclear war, limited or otherwise, on the climate are not perfectly certain. Detractors might argue there have been no catastrophic climate variances following roughly 2,000 nuclear tests since 1945. On the other hand the bulk of previous nuclear weapons testing was conducted "in the U.S. Southwest desert, on small tropical islands, at high altitudes, or underground,"[75] where there is little organic material, oxygen, or fuel to burn. Therefore, previous weapons testing offers little evidence to rebut the claimed effects of nuclear detonations on the climate, but it also offers little evidence to support the claims. Furthermore, scientific models simulating the effects of limited or total nuclear wars cannot be verified with independent evidence for the obvious ethical, logistical, and legal reasons, including that doing so would violate the provisions of the Partial Test Ban Treaty, which prohibits all nuclear tests except those performed under ground.

The lack of independent evidence does not mean the theories of Nuclear Winter or Nuclear Autumn is merely hypothetical. Robock and Toon seek out analogous evidence through the study of historical events that released substantial amounts of particles into the atmosphere. Burned cities, massive volcanic eruptions, large forest fires, and asteroid-earth collisions, such as the Yucatán Peninsula impact event that caused the extinction of the dinosaurs, can all be examined. Additionally, they argue the seasonal cycle is a natural simulation of the effects of reduced solar input.[76] A 2017 article in *Forbes* further states studying the effects of massive volcanic eruptions that burned sufficient vegetation or structures offers some insight. David Bressan highlights eruptions in Indonesia, Central America, and Iceland as candidates for causing the "Little Ice Age" during the 1200s, as well as an eruption in Indonesia in 1815 that caused the "Year without a Summer" in 1816, which spanned Eastern and Northern America to

[75] Toon (2007A), 24.
[76] Robock and Toon, 79-80.

Western Europe.[77] The 1815 eruption reddened the American sky, causing May and June frosts at higher elevations that triggered crop failures, thus reducing food supplies.[78]

The question is not whether or not nuclear explosions over metropolitan areas will affect the climate; the question is to what degree will it affect the climate. Robock, et al, modeled the effects of a regional nuclear war in 2007, finding the subsequent release of fine ash into the atmosphere cooled the global climate by 1.25 degrees Celsius,[79] which is a full degree cooler than the first year effect of the 1815 eruption on the global climate, with comparable effects on global temperatures through 1818.[80]

In summary, previous simulations both during and after the Cold War suggest a nuclear war, limited or total, will set fire to massive swaths of land. These fires will burn forests, structures, vegetation, and other organic and inorganic materials. The fires will likely produce fine black carbon ash that will rise into the atmosphere and block portions of solar rays for prolonged periods of time, resulting in cooler ground temperatures, shorter growing seasons, and drier climates, ultimately leading to greatly reduced crop yields lasting years. These affects are a function of total yield during the nuclear exchange—meaning total nuclear wars will likely lead to a Nuclear Winters and limited nuclear wars will lead to Nuclear Autumns. The effects on the climate are furthermore inescapable from social and psychological effects.

---

[77] David Bressan, "Even A Small Nuclear War Would Still Have Effects On Global Scale," *Forbes*, August 12, 2017, https://www.forbes.com/sites/davidbressan/2017/08/12/even-a-small-nuclear-war-would-still-have-effects-on-global-scale/#62f8de84507d.
[78] Clive Oppenheimer, "Climatic, Environmental and Human Consequences of the Largest Known Historic Eruption: Tambora Volcano (Indonesia) 1815," *Progress in Physical Geography* 27, no. 2 (2003): 244.
[79] A. Robock, L. Oman, G. L. Stenchikov, O. B. Toon, C. Bardeen, and R. P. Turco, "Climatic Consequences of Regional Nuclear Conflicts," *Atmospheric Chemistry and Physics* 7, no. 8 (2007): 2005.
[80] See Table 1, K. Briffa, P. Jones, F. Schweingruber, and T. Osborn, "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperature over the past 600 Years," *Nature* 393, no. 6684 (1998): 450.

Social Disruptions

A limited nuclear war, while not as deadly as a total nuclear war, will acutely result in massive human casualties. While the social effects are not as immediately recognizable as global climate effects, they have potential for global consequences. In 1975 Dr. Richard Garwin testified before the Subcommittee on Arms Control, International Organizations and Security Agreements, suggesting a limited nuclear exchange between the US and the Soviet Union would result in 16 million American dead.[81] The committee found this number to be unacceptable.[82] Since 1975 technological innovations have possibly driven this number up, although Toon, et al, predict the US would suffer 4 million fatalities.[83] The number of civilians killed in the blast, however, is not the whole picture of potential casualties and fatalities. To illustrate the potential impact, a novelist hypothesized a nuclear detonation over New Delhi in 2008, predicting the mass movement of millions of people, suffering from burn wounds and other injuries and seeking medical attention in an environment with essentially zero clean food or potable water.[84] Detractors might point to Hiroshima and Nagasaki and the residents' subsequent failure to migrate to rebut the claim that human beings will move en masse. On the other hand Japanese residents did not understand the radiological risks associated with returning to ground zero. Present-day knowledge of the negative health effects of radiation greatly increases the chances that mass human migrations will occur.

---

[81] United States, "Effects of Limited Nuclear Warfare Hearing before the Subcommittee on Arms Control, International Organizations and Security Agreements of the Committee on Foreign Relations, United States Senate, Ninety-fourth Congress, First Session," (Washington, D.C., September 18, 1975), 6.
[82] United States (1975), 1.
[83] Toon (2007A), 1224.
[84] Amitav Ghosh, *Countdown* (New Delhi: Pengui Books India, 2008), 80-81.

Other potential immediate and long-term effects include disrupting travel and shipping lanes, causing increased risk of cancer in areas near the explosions, and stymying entire fishing industries within a hundred miles or more of the affected coasts. Furthermore, the international community's trust in the nuclear-armed states will be greatly diminished.

More acutely important for survivors, even a limited nuclear war will result in decreased food supplies due to climate changes, as identified in the previous section. Food supplies can also be reduced because fallout will likely settle in farmlands, eradiating crops and livestock.[85] This will be especially painful to contemporary survivors of nuclear war that have eschewed Cold War-era unofficial policies of stockpiling non-perishable food products.[86] Economic structures risk collapse with mass migration and the large-scale destruction of industry, as well as the inability of banks to collect mortgages and insurance companies unable to cover the costs necessary to rebuild.[87]

It is likely some states will fail, particularly weak states or states acutely affected by nuclear war, plunging their societies into anarchy. With the aforementioned decrease in food supplies, society may turn to lawlessness because they will not be able to depend upon the state to provide basic food security. States unable to fulfill this basic role of food guarantor are often states making the failed state list.[88] Economic damages listed previously are likely to incense political stresses. The state's difficulty at collecting taxes may create a feedback loop where distrust of government will further divorce the citizen from the state, leading to more tax-

---

[85] Arthur Katz and Sima R. Osdoby, "Cato Institute Policy Analysis No. 9: The Social and Economic Effects Of Nuclear War," *CATO Institute*, April 21, 1982, https://object.cato.org/sites/cato.org/files/pubs/pdf/pa009.pdf.
[86] J Smith and T Smith, "Attitudes towards Civil Defence and the Psychological Effects of Nuclear War," *British Medical Journal (Clinical Research Ed.)* 283, no. 6297 (1981), 965.
[87] Smith and Smith, 965.
[88] "Could Food Shortages Bring Down Civilization?" *UPI Space Daily*, October 08, 2009.

collecting difficulties. This feedback loop could affect every aspect of government—its ability to repair broken water, electric, and communication lines; provide emergency services; treat the acutely radiated, people suffering related injuries after the explosions, and people suffering unrelated injuries and illnesses; and provide securities from neighboring states or groups wishing to exploit the chaos to secure resources for themselves.

In acutely affected regions, a final consequence of nuclear explosions is temporary or long-term damage to electrical systems, electronics, communication lines, and entire power grids. Electrical systems that survive initial blasts might be disrupted or taken off line by a blast effect known as an electromagnetic pulse (EMP). EMPs can cause physical damage to electrical or electronic systems by shorting capacitors or burning out transistors. Additionally, systems can suffer temporary disruptions. These disruptions might then disrupt entire power grids and take them off line, requiring manual labor to restore electricity and communications. EMP strength is a product of weapon size, number of weapons, and where they are detonated (air bursts produce smaller EMPs than ground bursts).[89] While there is little evidence of EMPs posing health risks to human beings, social disruptions might be further intensified by long- or short-term power failures and communications systems malfunctions.

In the case of a nuclear exchange between the United States and North Korea, it can be hypothesized that the peninsula will be partly uninhabitable. The blasts might kill between 100,000 and 1 million Koreans. Large-scale migration of survivors into China, Japan, and the South Pacific is likely, including Australia. With a combined population of roughly 75 million, it is reasonable to assume 10 to 20 percent of the peninsula's population will migrate—in other words between 7,500,000 and 15,000,000 migrants. It is possible the international community

[89] United States, "The Effects of Nuclear War" (Washington, D.C., 1979), 22.

can handle this migrant crisis easier than it could the Middle Eastern migrant crisis of 2015 to present, due to South Koreans sharing some of the same cultural values of the West and the North Koreans being seen as innocent victims of an oppressive regime, liberated by the West. This is unlikely for several reasons. First, can the West share? Due to the aforementioned decrease in available food resources globally, host nations could feel squeezed as the threat of starvation increases, particularly in acutely affected states. Second, as the Middle Eastern migrant crisis demonstrated in Europe, mass migration is correlated with the rise of nationalism,[90] which could be exacerbated by diminishing food supplies. In other words, sharing will likely be prioritized for in-group nationalities. Third, a shift towards nationalism amid a massive influx of Korean (and possibly Chinese and Japanese) migrants could potentially fulfill Samuel P. Huntington's *Clash of Civilizations* hypothesis that future conflicts will be between societies of differing civilizational values.[91] That is, a rise of nationalism sparked by diminishing food supplies and an influx of foreign nationals of differing ethnic and racial backgrounds could establish identities along ethnic lines, which could inflame racial tensions and increase crime.

In summary, a limited nuclear war will likely cause massive social disruptions, including mass human migrations either away from irradiated sites or towards food resources; failed states; and the rise of nationalism and clashes between disparate ethnic or racial groups. Furthermore, EMP blasts produced by nuclear weapons detonations causing long- or short-term power failures might exasperate social stresses. In the case of a limited nuclear war between the United States and North Korea, it can be assumed millions of Koreans will flee the peninsula, exasperating

---

[90] Claudia Postelnicescu, "Europe's New Identity: The Refugee Crisis and the Rise of Nationalism," *Europe's Journal of Psychology* 12, no. 2 (2016): 203-209.
[91] Samuel P. Huntington, *The Clash of Civilizations and the Remaking of World Order* (New York: Simon & Schuster, 1996).

tensions and resource struggles. All of these social disruptions will likely be made worse due to the effects of nuclear explosions on the climate.

Psychological Pressures

Surviving a nuclear war could have severe psychological impacts on human beings. As demonstrated during the subsequent decades following the attacks on Hiroshima and Nagasaki, surviving civilians sensed "personal vulnerability, helplessness, guilt, isolation and fear."[92] Helplessness and vulnerability are exasperated because nuclear attacks are extraordinarily difficult to defend against. If deterrence breaks down and a limited (or total) nuclear war is fought between two or more states, survivors have no expectation that deterrence can hold in the future. The fear of another volley of nuclear explosions will likely fill survivors with intense anxiety that the state cannot subside, no matter how robust it is in the aftermath. Survivor's guilt is another psychological response to witnessing "massive death and suffering," manifesting in "the cessation of normal human feelings."[93] Survivor's guilt develops if survivors of large-scale tragedies "believe they should not have survived or that they did something wrong by making it through the traumatic event" because "people overestimate their preexisting, predictive knowledge of the event."[94] In the event of a nuclear war, survivors might believe they could have done more to pressure their governments to practice restraint or take disarmament talks seriously. These feelings might be intensified if the survivor is a citizen of a democratic state and voted for the leader that gave the order to launch a first strike. This feeling could become so intense that

---

[92] Katz and Osdoby.
[93] Setsuko Thurlow, "NUCLEAR WAR IN HUMAN PERSPECTIVE: A Survivor's Report," *American Journal of Orthopsychiatry* 52, no. 4 (1982): 640.
[94] Jamie D. Mitchem, "Survivor Guilt," in *Encyclopedia of Disaster Relief*, ed. K. B. Penuel and Matt Statler (Thousand Oaks, CA: SAGE Publications, Inc., 2011), 662-664.

the survivor is incapable of social and economic performance.[95] On the other hand at least one anecdotal story from Hiroshima suggests survivor guilt is not universal, calling it an odd concept because it suggests "the idea that to be alive was a deviation from the norm of death and desolation."[96]

While any reconstruction would depend on uninjured survivors, these citizens might be suffering from severe psychological trauma that is only made worse by the climatological and social effects previously listed. The threat of future attacks, time spent in isolation, and dealing with the dead makes reconstruction more difficult, especially if the survivor re-enters a society that has fallen apart, is unable to rely on the government for assistance, and has limited access to life-sustaining resources.[97] The psychological stresses from all of these new realities is likely to deeply impact adult survivors and affect adolescent and young childhood.

Measuring the psychological effects of nuclear war is somewhat hypothetical; however, evidence exists from two main bodies of knowledge. First, psychological data was gathered from Hiroshima and Nagasaki. Second, there have been numerous large-scale natural and man-made disasters where psychological responses have been studied.[98] Contemporarily, data can be collected from failed states or collapsed societies, such as Aleppo or Mosul. Other sources of evidence include the 1990s siege of Sarajevo, the 2010 earthquake in Haiti, and the Great Chinese Famine during the 1950s and early 1960s. While studying these effects are on the relatively small scale of trauma, patterns of human behavior might emerge that confirm what can be expected following a disaster at the nuclear magnitude.

---

[95] Katz and Osdoby.
[96] Thurlow, 641.
[97] Smith and Smith, 964-965.
[98] Smith and Smith, 965.

Using the January 2010 magnitude 7.0 earthquake in Haiti as an example, numerous studies have examined its psychological consequences. For example, one study suggests roughly 37% of respondents experienced post-traumatic stress disorder, roughly 26% suffered depression, and roughly 13% suffered both.[99] Another study suggests these symptoms persisted at least 4 months following the earthquake.[100] Another study suggests children in Haiti, regardless of distance from the earthquake's epicenter, were sometimes twice as likely to suffer from trauma, anxiety, or depression.[101] If human psychology works to scale or larger-than-scale it can reasonably be assumed that the psychological trauma of a limited nuclear war will greatly surpass trauma from an incredibly destructive earthquake.

2.4 Recovery and International Conversation

Any discussion between nuclear states about test bans, arms control, and disarmament is usually met with skepticism at best and ridicule at worst, but there is evidence that unlikely discussions can emerge from human tragedy. Following the US and Soviet Unions' testing of thermonuclear weapons, testing accelerated, despite an international effort to reach a universal partial test ban. It was not until 1954, when the US accidentally irradiated Japanese fishermen aboard the ironically named *Lucky Dragon* that test ban talks were taken seriously. The fishermen were roughly 100 miles away from the 15-MT Castle Bravo nuclear test. Despite their

---

[99] Jude Mary Cénat and Daniel Derivois, "Assessment of Prevalence and Determinants of Posttraumatic Stress Disorder and Depression Symptoms in Adults Survivors of Earthquake in Haiti after 30 Months," *Journal of Affective Disorders* 159 (2014): 111-117.
[100] Ed Risler, Sara Kintzle, and Larry Nackerud, " Haiti and the Earthquake: Examining the Experience of Psychological Stress and Trauma," *Research on Social Work Practice* 25, no. 2 (2015): 251-256.
[101] Priscilla Dass-Brailsford, Rebecca S. Hage Thomley, Nicholas W. Talisman, Katherine Unverferth, and Bride, Brian E., "Psychological Effects of the 2010 Haitian Earthquake on Children: An Exploratory Study," *Traumatology* 21, no. 1 (2015): 14-21.

distance radiation from the explosion killed one sailor, and the crew suffered from acute radiation syndrome and severe dermal injuries. This incident was the third time in less than a decade that the US irradiated Japanese civilians (the first two occurring in Hiroshima and Nagasaki). This event spurred the international community, led by the Japanese Diet and the non-aligned movement, to seriously debate the legality of aboveground nuclear testing. Public opinion across the international community eventually pressured the US and the Soviet Union to sign the Partial Test Ban Treaty.[102]

Following a nuclear war there might also be domestic pressures influencing governments to take disarmament talks seriously. While North Korea and less-than-democratic regimes might be somewhat immune from the people's will, surviving democracies might face tremendous pressure to prevent a recurrence of nuclear exchange. With deterrence no longer a security guarantor through MAD, the populace might demand assurance that nuclear tragedy never happens again.[103] Among the surviving democratic states, analogous evidence takes several forms.

First, recent research suggests residing near the scene of a mass shooting makes the threat of gun violence more profound in the consciousness of the resident. This is coupled then with a heightened demand that governments take gun control debates seriously.[104] In the event of a nuclear war, limited or otherwise, distance from the epicenter collapses as a variable. In the age

---

[102] Georges Fischer, *The Non-proliferation of Nuclear Weapons* (London: Europa, 1971), 38.
[103] Indeed, democracies are likely to take disarmament talks extraordinarily seriously. George H. Quester cites Immanuel Kant's democratic peace theory and Francis Fukuyama's *End of History* as harbingers of a nuclear weapons-free world. See George H. Quester, "Nuclear proliferation and the elimination of nuclear weapons," in *Security without Nuclear Weapons? Different Perspectives on Non-nuclear Security*, ed. Regina Cowen Karp (Oxford; New York: Oxford University Press, 1992), 210.
[104] Benjamin J. J. Newman and Todd K. K. Hartman, "Mass Shootings and Public Support for Gun Control," *British Journal of Political Science* (2017): 1-27.

of ICBMs, strategic bombers, and SLBMs, the "bad guy with a gun" does not need to be lurking at the dark end of the street; rather, an attack can be initiated from any silo, near or far; any point in the vast oceans; or any airstrip. The threat of future nuclear wars becomes salient in the minds of voters because the dark end of the street is quite literally anywhere.

Second, Robert Pape's work in suicide terrorism research highlights a peculiar strategic logic of the suicidal terrorist as applied to democracies, and his conclusion is not without merit. A suicide terrorist can detonate a suicide vest if detected, eliminating the possibility of deterrence. This coupled with the fact that suicidal terror is difficult to predict or prevent, makes the threat very real in the minds of voters. Suicide terrorists furthermore have more success targeting the civilians of democratic regimes because the voting bloc demands security that might be elusive without bowing to the terror organization.[105] Israel, for example, is much more likely to give into the demands of terrorist groups than an authoritarian regime. Following nuclear war the voting bloc might demand the regime take disarmament talks seriously because security is elusive with nuclear weapons.

Third, seemingly improbable events can take place following massive traumatic events. Following World War II Europe's political landscape, once dominated by the balance of power, transformed into one of unity and integration. The traumatic effects of the rise of nationalism gave way to the emergence of the foundation that would become the European Union.[106] The idea that anarchy could be mitigated was not taken seriously until Europe suffered the immense cost of non-integration. Furthermore, the risk of future wars compelled the European community

---

[105] Robert Anthony Pape, *Dying to Win: The Strategic Logic of Suicide Terrorism* (New York: Random House, 2005), 44.
[106] Etienne Deschamps, "The Political Consequences," *CVCE*, July 8, 2016, https://www.cvce.eu/obj/the_political_consequences-en-bafcfa2d-7738-48f6-9b41-3201090b67bb.html.

to integrate West Germany into the European economic fold. In other words, rather than punishing the vanquished, West Germany was offered a seat at the table for the signing of the Treaty of Rome. The integration of Europe and subsequent creation of the European Union, as well as other collective security and intergovernmental agencies, might not have been possible if not for the mass human tragedy brought by the balance of power. The balance of terror, if it were to break down, might oblige societies towards the very difficult disarmament conversation.

Totalitarian and less-than-democratic regimes, while less susceptible to internal pressures, would still suffer many of the same consequences as democratic regimes. Furthermore, North Korea is likely to suffer more acutely than any other nuclear-armed state, given the current sociopolitical state of the world. If the state's primary interest is self-survival, the newly emerged fact that deterrence can break down is a compelling reason to desire re-stabilization by disarming. It is not unimaginable that even North Korea would willingly come to the discussion table if it survives a limited nuclear war.

Should deterrence break down between the US and North Korea or between any two belligerents (India and Pakistan come to mind), a perfect storm of human tragedy could take place. First, nuclear weapons would kill potentially millions of civilians and destroy massive amounts of infrastructure. Second, burned carbon might rise into the atmosphere, decreasing global temperatures, and leading to shortened growing seasons and lowered agricultural yields. Third, social systems could be stressed beyond their limits. And finally, individual psychological pressures could be strained to their breaking points. Due to nuclear weapons affecting global structures, such as the environment and economies, any nuclear war, including limited, is likely to have global consequences. This superfecta of tragedy is likely to overcome disarmament

skepticism and derision. Once societies have recovered, meaningful disarmament talks could take place in which even totalitarian regimes might participate.

2.5 Discussing Disarmament Now?

Disarmament is a difficult conversation. The fact that there have been no meaningful total disarmament talks speaks to the robustness of deterrence. On the other hand, there are several reasons deterrence can break down, which this chapter identifies. Should deterrence fail the result would be catastrophic, not merely for acutely affected states and societies, but also at the global level. States, societies, and individuals are likely to demand preventative actions. If disarmament no longer guarantees security, then nuclear weapons no longer serve their basic function. This chapter proposes that nuclear disarmament talks are not strictly the domain of the catastrophic consequences of nuclear war. States and societies can have the conversation without suffering intense tragedy.

Having this discussion before deterrence breaks down requires at a minimum three understandings. First, the logic of realist models brings us to the conclusion that nuclear weapons serve a function—deterrence. Deterrence serves a function—providing security. But realist models do not ask the questions: Can deterrence exist without nuclear weapons? Can security exist without deterrence? These questions are addressed in the Chapter 8, but for now, the questions should serve as a reminder that security is not limited by what simply works. Because systems can fail societies would be better to seek what works best.

Second, serious conversations about disarmament require robust models and simulations in many branches of science, psychology, and sociology. Decision makers would need access to those models and their methodologies, including impartial teams that can explain the findings of

models outside the leadership's expertise. In other words, in order to have a serious discussion, leaders would need to understand and accept the evidences from several fields of research. They should furthermore be encouraged to challenge the results with future replication models. Transparency at all scientific levels should serve as a trust building exercise.

Finally, detractors might fear cheating. Any serious disarmament discussion should confront the potential for cheating. Acton and Perkovich suggest using the threat of cheating to deter cheating. That is, if the best payout either side can receive is for both sides to cooperate and the worst is for both sides to defect, then the threat of retaliatory cheating should compel the other side to cooperate.[107] This does little to suggest how states can get to global zero, but it helps allay fears once zero has been reached.[108]

With these three understandings at the table, and with the acceptance that nuclear war, limited or total, is unacceptable, disarmament negotiations can take place. If states generally prefer not fighting nuclear wars to the alternative, then it is in those states' best interests to have the difficult disarmament discussion now rather than later. The evidences and models within a multidisciplinary scope serve as the foundation on which to begin the discussion.[109]

2.6 Summary

This chapter asks the questions: How can deterrence break down? What would a nuclear war look like in the modern day? And can decision makers take nuclear disarmament talks seriously? This chapter examines four non-mutually exclusive models of deterrence failure: First,

---

[107] George Perkovich and James M. Acton, *Abolishing Nuclear Weapons*, Adelphi Papers 396 (London: Routledge for The International Institute for Strategic Studies, 2008).
[108] This is explored in the Chapter 8.
[109] On the other hand, serious obstacles exist. These are identified in subsequent chapters and discussed at length in the Chapter 8.

mutual uncertainty pressures either side to strike first out of fear that they will receive a first strike. Second, non-credible threats can serve to encourage the stronger side to take out nuclear weapons sites to prevent itself from suffering an attack. Third, deterrence can break down by means of either side escalating conventional war, particularly if the war is zero sum. Finally, nuclear terrorism can lead to nuclear war due to either the attacked country retaliating against the host nation, or because nuclear terrorism can resemble a nuclear military attack. In other words, realist models of deterrence and stability are not necessarily as robust as they appear on the outside. These models are applied to the current crisis between North Korea and the United States.

This chapter next looks to the existing literature in atmospheric sciences, sociology, and psychology, determining a convergence of catastrophe should nuclear war take place. Models in various fields, using analogous evidence in some cases, suggest the worst-case scenarios even with a limited nuclear confrontation.

Finally, this chapter suggests that despite the difficulties surrounding disarmament talks, having a serious discussion is not unthinkable. Furthermore, simply understanding how painful a nuclear war would be at the global level can incentivize states and societies to have the discussion without first suffering through a nuclear war. It proposes that the international community could and should have the discussion now. If deterrence breaks down nuclear weapons lose all meaning above their military value. If deterrence can break down, then by what means do nuclear weapons have meaning now? The remainder of the dissertation uses fuzzy cognitive mapping models to explore the various scenarios of nuclear disarmament or not.

CHAPTER 3

BACKGROUND OF THE STUDY

This chapter discusses the background, philosophy of the methodology, and theoretical reasoning behind the study.

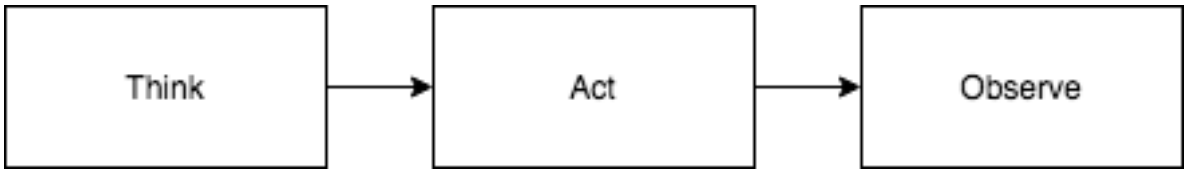
3.1 Structuring the Nuclear Disarmament Problem

This research draws heavily on systemic decision-making work by Patrick T. Hester and Kevin MacG. Adams. Their work in *Systemic Decision Making: Fundamentals for Addressing Problems and Messes* tackles complexity and how to think about problems and messes systemically. They call their approach "discipline-agnostic," arguing their methodology can be applied across fields, from business to the politics of science. International relations, as a subset of political science, which is itself a subset of the social sciences, is rife with complex problems that, at face value, appear to be impossible for human beings to solve. From multinational conflict to refugee crises, there is no shortage of complex problems facing the globe. Perhaps one of the most complex problems humans face is: *What do we do about nuclear weapons?*

As will be addressed in the second part of this literature review, nuclear weapons pose a dilemma; nuclear weapons provide security through deterrence, but nuclear weapons are so destructive that their use would shatter security. These are weapons of mass destruction, but a single total nuclear war would be so destructive that a better designation might be weapons of mass *extinction*. In other words a dialectic between security with deterrence and insecurity with deterrence emerges. The very thing that keeps states safe might be the thing that ultimately and utterly destroys states. Therefore, careful thought is necessary.

This chapter is divided into five subsections. First, the Think, Act, and Observe (TAO) approach is identified. This method is illustrated in Figure 3.1. Second, systems errors are discussed. Third, problems and messes are reviewed. Fourth, this research will discuss systemic thinking. Finally, fuzzy cognitive mapping, as a primary component of this research's methodology, is discussed. Fuzzy cognitive mapping is a methodology for modeling complex systems and is particularly useful in social problems.

Figure 3.1: Think, Act, Observe Approach (adapted from Hester and Adams)



Systems Errors

Hester and Adams provide a structured way to model problems big and small. It begins with a generalized way of understanding problems called the TAO approach, or Think, Act, and Observe.[110] When a problem presents itself practitioners will approach the problem in three steps. First, think about the problem. Second, act to try to solve the problem. Third, observe the action's outcome. After observation the Think phase reinitiates to understand whether the problem was solved. While in the real-world problems might be approached in less-than linear ways, this approach will serve as an approach to rational decision making, where decision makers have interest in the problem and its outcomes. The dialectic between security with deterrence and insecurity with deterrence is an enormous problem, and action should only be taken after careful consideration of the problem itself, devoid of systemic errors. Reasoning

[110] Hester and Adams, 3.

about this problem provides many opportunities to make one or more systems errors,[111] which could have catastrophic consequences. In Chapter 8 I will discuss feasible Type IV errors resultant from the model I build in Chapters 5 – 7. A list of these error types as identified by Hester and Adams is below. This list is not in sequential order because each error type is associated with a particular step in their TAO approach. The Type III error is typically associated with the Think step. Types IV, V, and VIII are associated with the Act step. Types I, II, and VI are associated with the Observe step. And Type VII is a collection of error types from any or all of the Think, Act, and Observe steps.

Type III Error (γ): This error type is associated with the Think step in the TAO approach. Mosteller defined the Type III error in 1948, identifying it as "correctly rejecting the null hypothesis for the wrong reason."[112] Mitroff calls it the "error associated with solving the wrong problem precisely."[113] This occurs when improper thought has been dedicated to the problem. For the purpose of this research, an example might be solving the nuclear weapons problem by creating an agency of international atomic scientists to administer and house all nuclear weapons without governmental oversight, but finding out afterwards that it has not solved the proliferation problem, leading to several proliferations and re-proliferations to guarantee states' security needs.

Mitroff identifies five common causes for committing the Type III error. They include selecting the wrong stakeholders; limiting problem-solving options; incorrectly formulating the problem; narrowly defining the scope of the problem; and focusing on a specific part, the wrong

---

[111] Hester and Adams, 4.
[112] Frederick Mosteller, "A k-Sample Slippage Test for an Extreme Population," *The Annals of Mathematical Statistics* 19, no. 1 (1948): 61.
[113] Ian I. Mitroff, *Smart Thinking for Crazy Times: The Art of Solving the Right Problems* (San Francisco: Berrett-Koehler Publishers, 1998), 15.

part, or missing connections between parts of the problem.[114] Avoiding the Type III error is crucial, and once the correct problem has been thought about, decision makers can move onto the Act phase, which can lead to many other error types.[115]

Type IV Error (δ): This error type is associated with the Act step in the TAO approach. The Type IV error occurs when a problem is solved correctly, but the effects of solving it are worse than the original problem. Marascuilo and Levin call this "the incorrect interpretation of a correctly rejected hypothesis."[116] Marascuilo and Levin use the example of "a physician's correct diagnosis of an ailment followed by the prescription of a wrong medicine."[117] Colloquially: "The cure is worse than the disease." For the purpose of this research, one could imagine a solution to the nuclear weapons problem being a monolithic world government, or a *Leviathan*,[118] that collapses sovereignty and imposes order over nations. While in such a system nuclear weapons have zero utility, the system would be so unrecognizable that it could only be accomplished through force and brutality against holdouts.

Adams and Hester argue that correctly curing the disease is instrumental.[119] As suggested, the international system following the Act step must be recognizable. Action must be taken within the system; the *Leviathan* would be to create a new, unrecognizable system that few would endorse.

---

[114] Mitroff, 20.
[115] Hester and Adams, 6.
[116] Leonard A. Marascuilo and Joel R. Levin, "Appropriate Post Hoc Comparisons for Interaction and Nested Hypotheses in Analysis of Variance Designs: The Elimination of Type IV Errors," *American Educational Research Journal* 7, no. 3 (1970): 398.
[117] Marascuilo and Levin, 398.
[118] Thomas Hobbes, *Leviathan, Or, The Matter, Forme and Power of a Common Wealth, Ecclesiasticall and Civil* [e-book], (London: Early English Books Online, 1651).
[119] Kevin MacG. Adams and Patrick T. Hester, "Accounting for errors when using systems approaches," *Procedia Computer Science* 20 (2013): 320-321.

Type V Error (ε): This error type is also associated with the Act step in the TAO approach. The Type V error occurs when a problem is correctly identified but no action is taken due to the erroneous belief that the problem will solve itself or go away on its own.[120] Competing stakeholders' inability to agree on the appropriate course of action or fear of committing the Type IV error could accentuate risk of the Type V error.[121] The problem is that "many problems require intervention in order to be addressed and simply wishing for a problem to disappear on its own will not make it go away. There is substantial risk in not acting when action is called for."[122] Using a car as an analogy again, a driver notices a clicking sound when making turns. Rather than spending money at the mechanic's shop for a diagnosis and potential solution, the driver opts to ignore the sound. A few months later the constant-velocity joint malfunctions, breaking the front axle, rendering the car inoperable. A small problem has become catastrophic because it was ignored.

The purpose of this project is to think systematically through the nuclear weapons problem, ideally in a way that will identify viable solutions, and thereby help the world avoid Type V errors.

Type VIII Errors (η): This error type is also associated with the Act step in the TAO approach. Type VIII errors occur when a correctly decided upon action is incorrectly acted upon. Hester and Adams note this is in contrast to willful violations of directed action, such as sabotage. Rather, they are the result of simple human mistakes.[123] For example, in 2013 the Lac-Mégantic derailment in Nantes, Quebec was caused when an engineer parked a train carrying

---

[120] Kim Boal and Mark Meckler, "Decision Errors of the 4th, 5th, and 6th Kind," in *Handbook of Decision Making: Blackwell Encyclopaedia of Management* [e-book], ed. Paul C. Nutt and David C. Wilson (West Sussex: Wiley, 2010), 398.
[121] Hester and Adams, 8.
[122] Hester and Adams, 7.
[123] Hester and Adams, 8.

crude oil on an incline and then improperly tested the handbrake system. The engineer knew the correct brake system test procedure, and intended to apply it, but failed to carry out all necessary steps.

Once types IV, V, and VIII errors have been reasonably avoided, decision makers can act and begin the Observation phase of the TAO approach.

Type I (α) and Type II (β) Errors: These error types are associated with the Observe step in the TAO approach and were first formulated by Neyman and Pearson in 1928.[124] Type I errors occur by rejecting the null hypothesis when the null hypothesis' condition is true (the false positive). A man walking alone in the woods at night can illustrate this. He hears the rustling of leaves and decides to turn around and go home in case there is an animal or person seeking to do him harm. In this case wind or a harmless rodent made the noise. The US committed a Type I error when it invaded Iraq partially on the incorrect belief that Saddam Hussein was manufacturing weapons of mass destruction

Type II errors occur by failing to reject the null hypothesis when the null hypothesis' actual condition is false (the false negative). Using the same analogy as above, the man hears the rustling of leaves and decides it must be the wind or a harmless rodent, when the actual condition is a brown bear seeking to eliminate a potential threat to its cubs. With nuclear weapons the US could make a Type II error if it assumes North Korea's nuclear arsenal cannot survive a first strike attack but turns out to be wrong.

Type I and II errors are committed due to adaptive bias. Reason is a product of human evolution, where humans are more likely to reason adaptively than rationally. Haselton and Buss posit that false positives and false negatives occur when reasoning the alternative is costly.

---

[124] Jerzy Neyman and Egon Pearson, "On the Use and Interpretation of Certain Test Criteria for Purposes of Statistical Inference: Part I," *Biometrika* 20A, no. 1/2 (1928): 175-240.

Furthermore, false negatives are more costly than false positives.[125] This creates a propensity for the Type I error, the false positive, a phenomenon explained in social psychology as the error management theory. This theory suggests that if the costs of false negatives outweigh the costs of false positives, then there should be a bias towards false positives.[126] With this in mind, it is reasonable to assume the man walking through the woods is more likely to commit the Type I error than a Type II error.

Type VI Error (θ): This error type is also associated with the Observe step in the TAO approach. Holland summarizes Type VI errors: "Correlation does not imply causation…"[127] In the TAO approach after action has been taken, practitioners might deduce that A caused B; however, the actual condition might be that B caused A, C might be a contributing factor to A or B, or the relationship between A and B could be a coincidence.[128] That is, causation is not as simple as decision makers might assume. For example, if two students spend the night before an exam cramming, and if both students receive a high grade on their exam, then it is possible to note a correlation between cramming the night before a test and receiving high grades; however, this does not mean that cramming causes high grades. In international politics there is certainly a negative correlation between mutual assured destruction and the number of wars fought between superpowers. On the other hand this does not mean that nuclear weapons cause superpowers to keep the peace. There is only one Cold War available for observation, and establishing causation

---

[125] Martie G. Haselton and David M. Buss, "Biases in Social Judgment: Design Flaws or Design Features?," in *Social Judgments: Implicit and Explicit Processes*, ed. Joseph P. Forgas, Kipling D. Williams, and William Von Hippel (New York: Cambridge University Press, 2003), 31.
[126] Martie G. Haselton, "Error Management Theory" in *Encyclopedia of Social Psychology*, ed. Roy F. Baumeister and Kathleen D. Vohs (Thousand Oaks, CA: SAGE Publications, Inc., 2007), 312-313.
[127] Paul W. Holland, "Statistics and Causal Inference," *Journal of the American Statistical Association* 81, no. 396 (1986): 945.
[128] Hester and Adams, 10.

would require many more Cold War observations or the impossible option to experiment by randomly assigning nuclear weapons to some superpower rivalries but not others.

Type VII Error (ζ): The Type VII error is a system of errors, where types I-VI and VIII errors "compound to create a larger, more complex problem than originally encountered."[129] The consequences of Type VII errors include no longer being able to recognize the original problem, difficulty diagnosing the problem, decreased problem-solving resources or desire to solve the problem, difficulty identifying the solution, and decreased capability to solve the problem.[130] The initial problem can become so complex with improper formulation, wrong action, and faulty observation that problem solving enters the realm of chaos. This is a worst-case scenario that should be practitioners' largest concern.[131]

Hester and Adams offer some guidance. Categorizing error types according to the TAO approach, practitioners can come better prepared. Type III errors are associated with thinking. In order to avoid making this error, the problem and its parameters must be carefully considered. Type IV, V, and VIII errors are associated with acting. Avoiding these errors means acting correctly and when warranted, correctly carrying out the action decided upon, and choosing the appropriate course of action. Type I, II, and VI errors are associated with observation. To avoid these errors practitioners should consciously consider each error type, using available statistical tools and careful consideration of the evidence.[132]

Table 3.1 below is an illustration of the potential for making systems errors and a system of errors. Country A feels threatened by Country B's expanded military capabilities. Country B might or might not have malicious intent behind its expanded capabilities. Regardless, Country

[129] Hester and Adams, 10.
[130] Boal and Meckler, 336.
[131] Hester and Adams, 11.
[132] Hester and Adams, 12.

Table 3.1 Nuclear Proliferation Problem Example (adapted from Hester and Adams).[133]

TAO Stage	Situation Description	Potential Errors
Think	Country A feels its security is threatened because Country B has expanded its military capabilities.	Type III
Act	Country A creates an advisory board of nuclear physicists and engineers.	Types IV, V, VIII
Observe	The board listens to Country A's concerns and collects information from other scientists and engineers.	Types I, II, VI
Think	Based on the information collected from the leader and other sources, the board reasons about possible steps moving forward. The board recommends building centrifuges to enrich uranium and other materials.	Type III
Act	Country A invests in uranium enrichment facilities.	Types IV, V, VIII
Observe	The international community observes Country A's uranium enrichment activities and imposes sanctions because it does not approve of nuclear proliferation to solve international disputes.	Types I, II, VI
Think	Given the reduced flow of capital to fund proliferation, the board (not wanting to lose their jobs) recommends Country A find alternative funding through black market deals with criminal enterprises.	Type III
Act	Country A engages with criminal enterprises to enter black markets.	Types IV, V, VIII
Observe	With new capital flows Country A observes it can continue its uranium enrichment activities.	Types I, II, VI
Etc.	Country A continues to think, act, and observe. Meanwhile the original problem might go away (Country B's military capabilities might no longer pose a threat to Country A), but the danger of recurrence continues. Thus, Country A continues to devote resources to nuclear proliferation and might eventually successfully test a nuclear weapon. The international community continues to respond to Country A's proliferation attempts.	Types I-VIII

[133] Hester and Adams, 13.

A spends resources creating a nuclear advisory board without properly thinking about Country B's intent. If country A made a Type III system error, then the problem can spiral out of control to make a system of errors.

The above example does not necessarily reflect reality. Some states proliferate for reasons other than the balance of power. Others might abandon their weapons program to avoid sanctions or because the nuclear taboo imposes other costs on proliferators.

A major part of the focus of this research is to solve the nuclear weapons problem without committing a Type III error. That is, successfully solving this problem begins by analyzing the original problem formulation. Thinking about nuclear weapons systemically will help formulate the correct problem. In the above example, the formulated problem was that Country A's security was threatened by Country B. Using realist logic it is easy to see how nuclear weapons have value, but if nuclear weapons solve the wrong problem precisely then what is an alternative problem? By formulating the correct problem the practitioner can then act, making sure that they act correctly and act when warranted. It is at this stage that we observe.

Hester and Adams propose a probability function to determine the likelihood that the problem was correctly formulated.[134] There is a probability that any given error type is committed in each respective step in the TOA approach.

$$P(correct\ problem) = 1 - [[1 - P(\gamma)][1 - (P(\delta) + P(\varepsilon) + P(\eta))]\big[1 - \big(P(\alpha) + P(\beta) + P(\theta)\big)\big]]$$

[134] Hester and Adams, 13.

In laymen terms, the probability that the correct problem was formulated shrinks drastically if any systems error types are committed. As each Think, Act, and Observe step is repeated, the probability of a correct problem can become quite small. This reinforces the need to more carefully consider the underlying problem(s) behind why countries proliferate and presently refuse to disarm.

At the extreme end of error consequences, deterrence breakdown could imply that the initial problem was incorrectly formulated, deterrence was incorrectly implemented, or deterrence was incorrectly assumed to cause security, rather than being merely correlated with security. A correct candidate problem might be: Country A and Country B have a dispute over Resource X. Despite whether or not a Type III error was made in the initial Think step, finding out requires observation. The major takeaway is that formulating the correct problem is of the utmost importance. Correctly inferring from observation is reliant on getting the problem right.

Problems and Messes

In 1967 Charles West Churchman referenced Horst Rittel as the author of the phrase "wicked problem." A wicked problem, he writes, is a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing."[135] Rittel and Webber expanded on the idea of the wicked problem in 1973, adding they cannot be definitively formulated, lack a recognizable end point (unlike a game of chess, where both players recognize when the game is over), are ideologically driven, produce butterfly effect consequences over long periods of time, and cannot be solved by trial and error; but rather

[135] Charles West Churchman, "Wicked Problems," *Management Science* 14, no. 4 (1967): B-141.

a single attempt.[136] In the systems age, discussed below, wicked problems might have stakeholders with divergent interests and perspectives, conditions that change rapidly, and difficulties that disrupt viable paths forward.[137]

In order to formulate the problem correctly several steps should be taken. First, nuclear weapons are not part of a "machine age" problem. Instead, the problem exists in a "systems age." Whereas machine age problems are simple, systems age problems are complex.[138] In other words, disarmament is not as simple as physically dismantling nuclear weapons; rather, the ability for human agents to dismantle nuclear weapons requires a more holistic treatment of the complex system in which they exist. Agency drives complex systems; therefore, human beings *must* be included in full problem formulation.[139]

Bringing humans in creates a paradox. While humans are essential parts of the system, and because humans have many different perspectives about reality, it is not necessarily true that a researcher can understand each perspective, yet understanding perspectives is necessary in the systems age. Bohr, therefore, proposes the principle of complementarity: "Two different perspectives or models about a system will reveal truths regarding the system that are neither entirely independent nor entirely compatible."[140] In other words, in agency-driven problems there are no universal realties; therefore, solving them requires some level of contextual understanding.

---

[136] Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4, no. 2 (1973): 161-163.
[137] Hester and Adams, 20.
[138] Russell L. Ackoff, "The Systems Revolution," *Long Range Planning* 7, no. 6 (1974): 2-20.
[139] Russell L. Ackoff, "The Future of Operational Research Is Past," *The Journal of the Operational Research Society* 30, no. 2 (1979): 100. Hester and Adams, 19.
[140] N. Bohr, "The Quantum Postulate and the Recent Development of Atomic Theory," *Nature* 121, no. 3050 (1928): 580-590.

$$Contextual\ Understanding = \sum_{i=1}^{n} P_i$$

where $n \neq \infty$, and a perspective about the problem is a function of the number (i) of perspectives (P_i).[141]

In other words, as the number of observed perspectives increases, our understanding increases. Perfect understanding, however, is essentially impossible, particularly because there are potentially 7.7 billion stakeholders affected by the existence or potential elimination of nuclear weapons at any given time, each with varying levels of capability, influence, and legitimacy. Increasing the value of contextual understanding of the major stakeholders is an essential and basic element to this research, but care should be taken to avoid raising the fidelity too much by bringing in extraneous variation (such as differences between state leaders, government types, etc.), which violates basic tenets of realist though (discussed later).

Interestingly, the human perspective paradox increases a study's validity, both in terms of scientific robustness and philosophical meaning. For example, the disparity between the perspectives of nuclear weapons proponents and abolitionists at the extremes offers this study the ability to collect more information that either confirms or disconfirms its hypotheses, meaning that hypotheses can better stand up to scientific scrutiny.[142] Mitroff and Linstone expound a scientific appreciation for multiple perspectives. They write, "everything interacts with everything," and that systemic thinking requires "the widest possible array of disciplines, professions, and branches of knowledge—capturing distinctly different paradigms of

[141] Hester and Adams, 22-23.
[142] Hester and Adams, 24.

thought…"[143] Mitroff and Linstone thus capture the nuclear weapons dialectic, *a la* Plato and Aristotle at Raphael's *School of Athens*. Divergent perspectives create theses and antitheses seeking synthesis. Jumping from the dialectic, divergent perspectives are central to Thomas Kuhn's *Scientific Revolutions*, where anomalies in normal science give way to revolutionary science.[144] That is, realist models of nuclear proliferation and balance of power, as discussed later, face anomalies in the form of disparate perspectives about nuclear weapons' threat and utility. Balance of power is normal science, while contrasting perspectives inhabit revolutionary science in the minds of abolitionists. I can reasonably hypothesize that synthesis between the two paradigms is possible.

Therefore, Hester and Adams propose a holistic approach to addressing wicked problems or "messes" in the systems age, where hard and soft approaches are combined. They write, "A hard system perspective includes notions such as objectivity, unitary viewpoints, and quantitative assessment; while a soft systems perspective evokes subjectivity, pluralistic perspectives, and qualitative assessments."[145] That is, the hard approach is technical and suited for machine age problems, such as systemic pressures under anarchy, while the soft approach captures socially constructed realities and human factors and is better suited for systems age "messes". The holistic approach therefore requires the identification of the problem this research attempts to solve as well as its constituent problems.

Gerald Smith identifies a problem's three main criteria: First, a gap exists between the present and desired states of the world. Second, closing that gap is difficult. Third, solving the

---

[143] Ian I. Mitroff and Harold A. Linstone, *The Unbounded Mind: Breaking the Chains of Traditional Business Thinking* (New York: Oxford University Press, 1995), 91.
[144] Thomas Kuhn and Ian Hacking, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962).
[145] Hester and Adams, 24.

problem, or closing the gap, is desirable for at least one actor.[146] Sage adds a fourth criterion: At least one stakeholder views the problem as solvable.[147] Pidd adds that problems in the social context have no single correct answer; rather, answers are conditional on how the problem solver perceives it.[148] With multiple, equally valid perceptions of the problem and its solution, Pidd adds that the optimal, or even an acceptable, solution requires some level of expertise and ingenuity.[149]

Additionally, problems have owners. Problem ownership is reflected in Smith's third criterion for problem identification. Beyond merely wanting to see the problem solved, problem owners are willing to dedicate resources to solving the problem. Hester and Adams note that ownership does not necessarily mean the owner has the authority to allocate resources.[150] For example, a wealthy A-list celebrity might have the resources necessary and the willingness to host a nuclear weapons summit at his estate; however, he does not have the authority to compel state leaders (decision makers) to attend.

Problems do not necessarily exist in a vacuum. Systems of problems can exist. A system of problems is referred to throughout this text as a "mess." A "mess" is a system of problems "with multiple stakeholders who may hold quite different views on what is feasible and desirable."[151] Moreover, stakeholders might disagree on the mess' contours, meaning "both the

---

[146] Gerald F. Smith, "Towards a Heuristic Theory of Problem Structuring," *Management Science* 34, no. 12 (1988): 1491.
[147] Andrew Sage, *Systems Engineering* (New York: Wiley-Interscience, 1992), 232.
[148] Michael Pidd, "Complementarity in Systems Modeling," in *Systems Modeling: Theory and Practice*, ed. Michael Pidd (Wiley, 2004), 44.
[149] Pidd (2004), 7.
[150] Hester and Adams, 27.
[151] Michael Pidd, *Tools for Thinking Modelling in Management Science*, 3rd ed., (Chichester, U.K.: Wiley, 2009), 44.

problem formulation and methods to address it are potentially in conflict."[152] Mess articulation, therefore, can be difficult, as opposed to the problem's articulation. James Greeno captures this difficulty: "When a problem has an indefinite goal, the problem solver cannot know what the solution state will be like until it is achieved—or at least until some progress has been made" and "Indefinite goals seem to be an important factor in producing the weakness of structure in many ill-structured problems."[153] This differentiates messes from problems because problems' goals can be succinctly stated. Without a succinct desired end state, there can be no practical, empirical solution, and generalized solutions cannot be empirical.[154] Newell, et al, demonstrate this:

> I want to take my son to nursery school. What's the difference between what I have and what I want? One of distance. What changes distance? My automobile. My automobile won't work. What's needed to make it work? A new battery. What has new batteries? An auto repair shop. I want the auto repair shop to put in a new battery; but the shop doesn't know I need one. What is the difficulty? One of communication. What allows communication? A telephone…And so on.[155]

That is, in Newell's anecdote, he cannot articulate the solution to his situation succinctly. While driving to the nursery school is a succinct solution to one problem of his mess,[156] it does not solve the communication problem. Likewise, using the telephone to call the automobile repair shop does not get his son to nursery school. In this case using the phone to call the repair shop is

---

[152] Hester and Adams, 27.
[153] James G. Greeno and George Mandler. "Indefinite Goals in Well-structured Problems," *Psychological Review* 83, no. 6 (1976): 480.
[154] Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," *Proceedings of the London Mathematical Society* 42, no. 1 (1937): 246.
[155] A. Newell, J.C. Shaw, and H.A. Simon, *Report on a General Problem Solving Program*, Technical Report No. P-1584 (Santa Monica, CA: RAND Corporation, 1959), 8-9.
[156] It must be noted here that this is merely for illustration and does not constitute a mess because the same actor owns each of the problems. Hester and Adams, 28.

merely a single step Newell can take to get him closer to his desired state, dropping his son off at the nursery school.

The decision to pick up the phone to ring the repair shop was one of many possible solutions to the immediate communication problem. Newell could have walked to the repair shop. These two solutions make up his problem space, which "may include several intermediate steps which each move your current state some amount closer to your desired end state."[157]

With the definitions of problems and messes made clear, I now turn to the final part of this subsection: structuring problems.

Because this research wishes to avoid making a Type III Error at the beginning, or "solving the wrong problem precisely," I must discuss structuring problems. This is important because it helps develop a holistic understanding of the proposed mess. Problem structuring methods "help a series of divergent stakeholders to understand the complex problem they face *before* attempting to resolve it…"[158] That is, it helps stakeholders understand the actual problem.

The goal is to break a mess down into its constituent problems. But Pidd points out that this does not imply the problems are separate.[159] That is, a mess is made up of individual problems. For example, a war is a mess. It is made up of several problems (e.g., there is a disparity between states over rights to some resource, there is no consensus as to how the conflict should be resolved, there might be domestic anti-war movements pressuring governments participating in the war, etc.). All the mess' component problems are linked and are not isolated. Using problem-structuring methods, therefore, can help address issues, such as "multiple actors, differing perspectives, partially conflicting interests, significant intangibles, [and] perplexing

---

[157] Hester and Adams, 28.
[158] Hester and Adams, 29.
[159] Michael Pidd, "From Problem-Structuring to Implementation," *The Journal of the Operational Research Society* 39, no. 2 (1988): 116.

uncertainties."[160] This does not imply that problem-structuring methods make the process simple. It remains no easy feat.

Hester and Adams propose that problem structuring requires an appreciation of the problem's "underlying purpose of its associated system."[161] What are the stakeholders' true concerns? Who are the decision makers and the problem's owners? What are the structural forces behind the problem? What triggers those forces? Blanchard suggests "Defining the problem is sometimes the most difficult part of the process, particularly if one is in a rush to 'get going.'"[162] The problems might be extraordinarily large; Mitroff suggests it might be better to define the contours of the problem outside the researcher's comfort zone in order to make sure the researcher has fully captured the problem.[163] The bottom line: If the problem is large, the structured problem should be large enough to capture the entire problem.

Thinking Systemically

Holistic thinking in the systems age traces its roots to the early 20th century; however, it came to prominence during the late 1930s and early 1940s, when complex technical and political problems during WWII required more than simple mechanical solutions. The joint American and British field was called Operations Research (OR). OR has no precise definition, and many definitions overlap. Charles Kittel was first to define it. He writes, "Operational Research is a

---

[160] J. Rosenhead, "Past, Present and Future of Problem Structuring Methods," *The Journal of the Operational Research Society* 57, no. 7 (2006): 759.
[161] Hester and Adams, 30.
[162] Benjamin S. Blanchard, *System Engineering Management*. 3rd ed., (Hoboken, NJ: John Wiley, 2004), 48.
[163] Mitroff, 21.

scientific method of providing executive departments with a quantitative basis for decisions."[164] Despite its lack of coherent definition, and despite Kittel's vague definition, what it does is more or less definable. It employs methods from various fields of research, such as mathematics, chemistry, engineering, physics, psychology, management, economics, and social sciences. It seeks to apply scientific methods, using quantitative analysis to support managerial decisions. Saul Gass has a good summary of the history of OR and discusses the evolution of OR during WWII from first being used to develop antiaircraft guns and submarine hunting systems to its subsequent expansion into business and industry.[165]

While Gass' article is somewhat optimistic about the future of OR,[166] Hester and Adams argue that as complexity increases, particularly by bringing in many different viewpoints, the need for new approaches increases.[167] As the Type III error warns, this reinforces the need to do the "right problem" before doing the "problem right."[168] In other words, research must avoid the Type III error before it can hope to solve the problem. Hester and Adams refer to this as hard OR (doing the problem right) and soft OR (doing the right problem), and with increased complexity comes increased need to be doing both the right problem and the problem right.[169]

Doing the right problem, as Mitroff previously points out, means capturing all the parts of the problem, even if it means bringing in things beyond the visible edges of the problem. Hester and Adams expand, demonstrating that a mess is made of constituent problems, but the

---

[164] Charles Kittel, "The Nature and Development of Operations Research," *Science* 105, no. 2719 (1947): 150.
[165] Saul I. Gass, "Model World: On the Evolution of Operations Research," *Interfaces* 41, no. 4 (2011): 389-393.
[166] See concluding paragraphs. Gass, 393.
[167] Hester and Adams, 37.
[168] N. J. Curtis, P. J. Dortmans, and J. Ciuk, "'Doing the right problem' versus 'doing the problem right': problem structuring within a Land Force Environment," *The Journal of the Operational Research Society* 57, no. 11 (2006): 1301
[169] Hester and Adams, 38.

constituent problems might not make up the entire mess. Assume a mess (M_1) is made of five problems ($P_1, P_2, \ldots P_5$). However, solving the mess is not the summation of solving the constituent problems:[170]

$$M_1 = \mathrm{f}(P_1, P_2, \ldots P_5) \neq \sum P_i$$

It is here where viewing the mess as a system with interacting component parts becomes necessary because the interaction between the problems adds to the mess' condition. The behavior of the mess is greater than the sum of its parts. Ackoff summarizes this reality:

> Problems are elements abstracted from messes; therefore, problems are to messes what atoms are to planets. There is an important systems principle, familiar to all of you, that applies to messes and problems: that the sum of the optimal solutions to each component problem considered separately is not an optimal solution to the mess. This follows from the fact that the behavior of the mess depends more on how the solutions to its component problems *interact* than on how they act independently of each other.[171]

It is therefore true that handling the mess does not mean optimizing each problem. Hester and Adams propose satisficing, or "acceptable compromises." This means it is an unfortunate reality that finding the best solution is often not possible. Rather, they point out, the goal of systemic thinking is "to resolve or increase our understanding of a mess…"[172] For instance, while this might upset the Global Zero Movement if the reality is that the system is stable, and

---

[170] Hester and Adams, 42.
[171] Russell L. Ackoff, "Optimization + Objectivity = Opt Out," *European Journal of Operational Research* 1, no. 1 (1977): 4-5.
[172] Hester and Adams, 43.

nothing can be done to abolish nuclear weapons, finding equilibrium in the present state helps us avoid making the Type IV error, or destabilizing the system with an inappropriate intervention.

It is also true that inherent in a mess, given the divergence of perspectives, is the necessity to treat the system as pluralistic (divergent viewpoints where compromise is possible) or coercive (divergent viewpoints were compromise is not possible).[173] This is due to the subjectivity of the system. While objective systems have unitary actors (convergent viewpoints), messes are subjective social interactions where an optimized solution that satisfies everyone is not possible.

Finally, Hester and Adams propose a multimethodology for systemic decision-making.[174] That is, they borrow four processes that structure complex problems from Millet and Gogan: groping, structuring, adjusting, and unstructuring.[175] Groping is taking incremental steps to impose structure on highly ambiguous problems. Structuring occurs when the state changes from unstructured to structured. Adjusting is adding or removing constraints incrementally, while maintaining a high level of structure. Unstructuring involves changing the state from structured to unstructured. Millet and Gogan caution that these steps do not necessarily, and indeed rarely, occur linearly. They may "cycle through a complex sequence of groping, structuring, adjusting and unstructuring before resolution is achieved."[176]

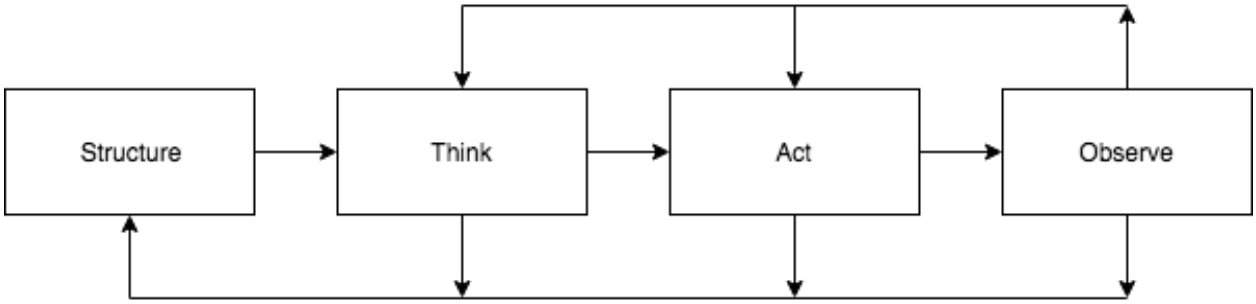
From the structuring phase, it is also rarely a linear procession from structuring to the Thinking, Acting, and Observing, as illustrated in Figure 3.1. Instead, as shown in Figure 3.2,

---

[173] Hester and Adams, 48.
[174] Hester and Adams, 48.
[175] I. Millet and J. L. Gogan. "A Dialectical Framework for Problem Structuring and Information Technology," *The Journal of the Operational Research Society* 57, no. 4 (2006): 435.
[176] Millet and Gogan, 435.

practitioners follow a nonlinear process where steps occur out of sequence, where feedback occurs.[177]

Figure 3.2: Systemic decision making flow chart (adapted from Hester and Adams [p. 50])



3.2 Summary

Solving the nuclear weapons problem requires more than what traditional international relations theory can offer. This chapter outlines the philosophical approach to the methodology that is explained in the next chapter. As a practitioner carefully thinks about the problem, he or she should attempt to avoid the Type III error. One cannot solve a problem easily if they are trying to solve the wrong problem. Other error types are identified, and avoiding them, particularly the Type IV error, which could result in nuclear catastrophe, further complicates the methodology.

Further, this chapter highlights that the nuclear weapons problem is not merely a single problem; rather, it is a system of interacting problems, or a "mess." Solving each of the "mess'" constituent problems individually does not necessarily resolve the "mess," but might instead commit a Type IV error. Therefore, care should be taken to structure and think about the mess in a way that captures problem interaction in order to avoid the Type IV error.

[177] Hester and Adams, 49-50.

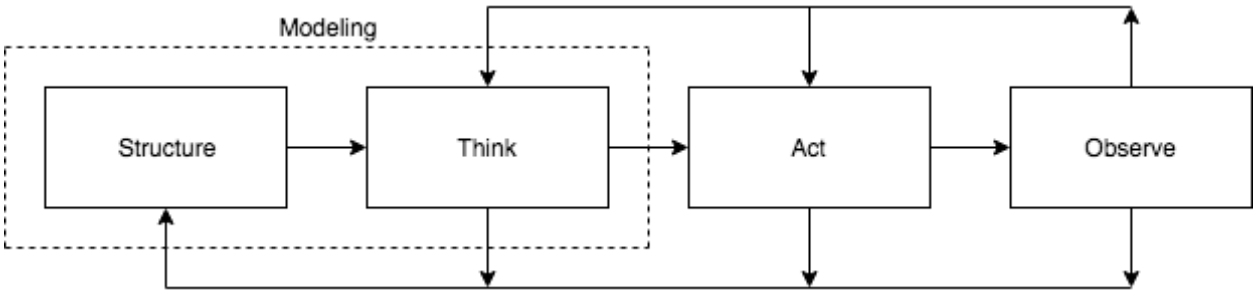
CHAPTER 4

METHODOLOGY

Drawing from Hester and Adam's Structure-TAO approach, this project is a combination of modeling real-world problems (a system) as well as various simulations within the proposed real-world system (see Figure 4.1).[178] That is, this project seeks to model and experiment with an abstraction of the real-world system in which the nuclear weapons problems exist. To accomplish this, this project uses fuzzy cognitive mapping.

4.1 Fuzzy Cognitive Mapping

Figure 4.1 Modeling in Systemic Decision Making



Fuzzy cognitive mapping (FCM) is adapted from Robert Axelrod's cognitive mapping, which is a graphical representation of a system's elements as points or nodes, which have causal links between them (represented as arrows or links).[179] In Axelrod's modeling, nodes can increase, decrease, or have no effect on other nodes. This trivalent logic, where positive relationships take on a value of 1, negative relationships take on a value of -1, and no

[178] Hester and Adams, 103.
[179] Axelrod, 5.

relationship is represented by 0, can be illustrated with the following model and matrix (Figure 4.2 and Table 4.1):

Figure 4.2: Cognitive Map Example

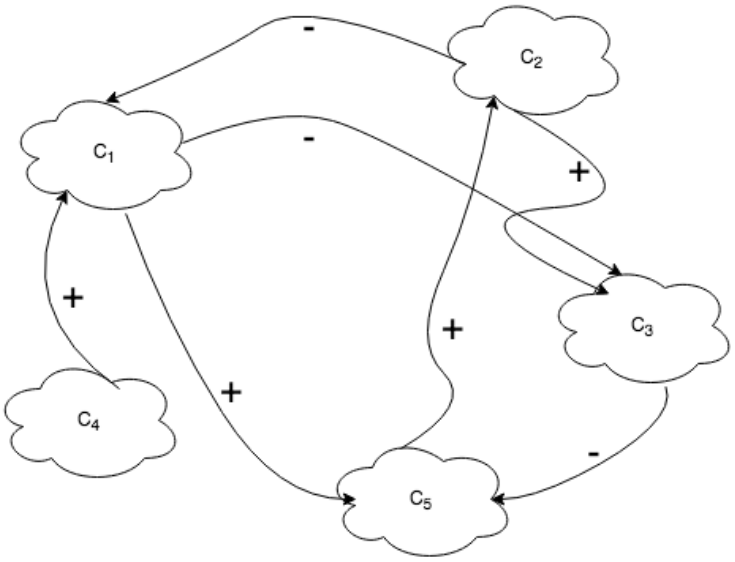


Table 4.1: Cognitive Map Example Matrix

	C1	C2	C3	C4	C5
C1	0	0	-1	0	1
C2	-1	0	1	0	0
C3	0	0	0	0	-1
C4	1	0	0	0	0
C5	0	1	0	0	0

This is a set of strict causal relationships between components. C_1 decreases C_3 and increases C_5; C_5 increases C_2, and so on. This form of modeling captures the direction of the relationship but not the strength. Therefore, Bart Kosko overcomes some of the limits in assigning causality by allowing "hazy degrees of causality between hazy causal objects

(concepts)."[180] That is, he addresses relationships that can influence a receiver component "a little bit" or "a lot" by some number defined on [-1, 1].[181] Figure 4.3 and Table 4.2 illustrates this.

Figure 4.3: Fuzzy Cognitive Map Example

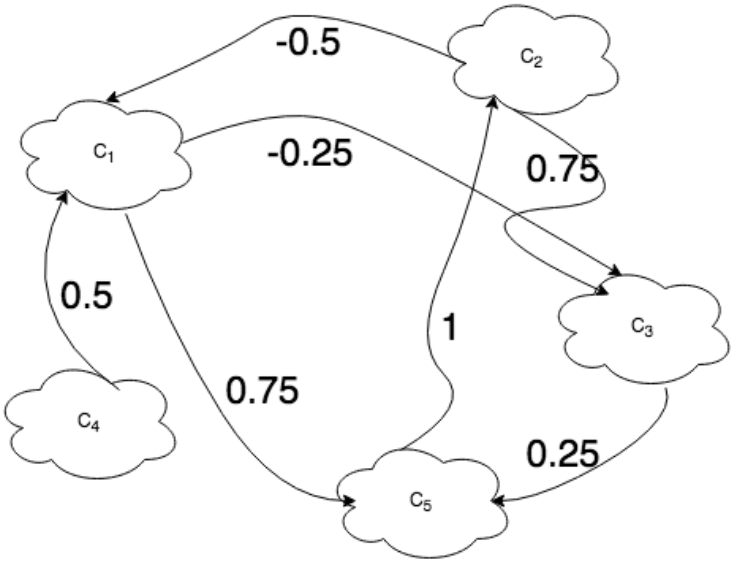


Table 4.2: Fuzzy Cognitive Map Example Matrix

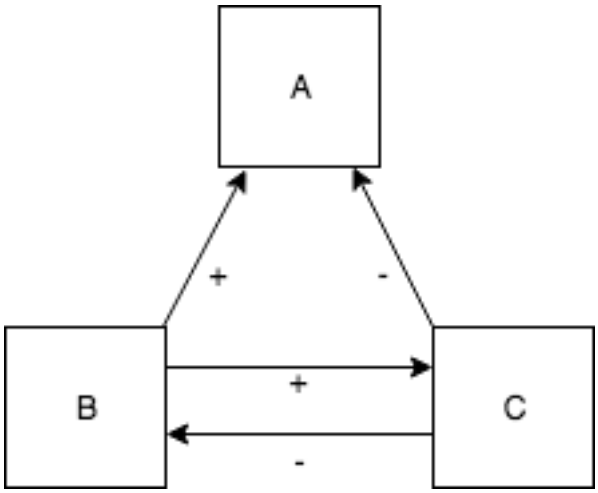
	C1	C2	C3	C4	C5
C1	0	0	-0.25	0	0.75
C2	-0.5	0	0.75	0	0
C3	0	0	0	0	0.25
C4	0.5	0	0	0	0
C5	0	1	0	0	0

[180] Kosko, 65.
[181] Kosko, 67.

The benefits of using the FCM are that they visually represent the real world, allow simulation, and can be qualitatively assessed. Furthermore, unlike Multiple Criteria Decision Making,[182] FCM allows for feedback loops and "can suggest alternatives through exploratory analysis," and unlike systems dynamics, FCMs can rely on situations where data is lacking.[183]

Hester and Adams work through the mathematical underpinnings of FCM modeling, where, "FCMs evolve over time … and can be analyzed relative to this evolution."[184] In their example, they show three nodes, *A*, *B*, and *C*.[185] The weight of the influence, or the matrix, of *B* or *C* on *A* is represented by *W*.

Figure 4.4: FCM Weights Example



In Figure 4.4, the state of *A* at step $t + 1$ is a function of A^t and *W*:

[182] This is a formal decision-making framework that examines problems with elements in conflict that require trade-offs. For example, a person needs a car, and they want both the sportiest car at the cheapest price. These variables contradict the other. See Stanley Zionts, "MCDM—If Not a Roman Numeral, Then What?," *Interfaces* 9, no. 4 (1979): 94.
[183] Hester and Adams, 104-105.
[184] Hester and Adams, 108.
[185] Athanasios K. Tsadiras, "Comparing the Inference Capabilities of Binary, Trivalent and Sigmoid Fuzzy Cognitive Maps," *Information Sciences* 178, no. 20 (2008): 3884.

$$A^{t+1} = f(A^t W)$$

Where "*f* is known as a transfer function used to evolve the FCM from one timestamp to the next."[186] In short, by altering one or more independent variables, the dependent variables take on values from timestamp to timestamp as a result of their initial value and the weights affecting the component. To illustrate this effect, consider a car driving in a straight line at a constant speed. If you want to know where the car is, figure out where the car started and how fast it was traveling. Its starting point and its speed determine its present location. To round out this analogy, the combustion engine is a suitable transfer function *f*, even though non-combustion propulsion is also available.

Tsadiras says the most common forms of *f* are binary, trivalent, and sigmoid.[187] Using the binary function allows movement along the edges of 0 and 1. He adds, "Binary FCMs are suitable for highly qualitative problems where only representation of increase or stability of a concept is required."[188] The trivalent function allows variables to take on -1, 0, or 1 values, where qualitative problems require a representation of decrease, stability, or increase. The sigmoid function allows continuous movement between -1 and 1, inclusively. This captures qualitative or quantitative problems, "where representation of a degree of increase, a degree of decrease, or stability of a concept is required and strategic planning scenarios are going to be introduced."[189] This is demonstrated in the following equation.

[186] Hester and Adams, 108.
[187] Tsadiras, 3885.
[188] Tsadiras, 3894.
[189] Tsadiras, 3894.

$$f_{\text{sig}}(x) = \tanh(\lambda x) = \frac{e^{\lambda x} - e^{-\lambda x}}{e^{\lambda x} + e^{-\lambda x}}$$

where λ represents a user-defined constant value for the sigmoid function's slope. For the purpose of this research, the sigmoid function is the most suitable. Bueno and Salmeron suggest a λ value of 5 as this value "provides a good degree of normalization…" while a value of 10 closer resembles a trivalent function, and a value of 1 or 2 is close to linear.[190]

In this project, the above formula for the sigmoid transfer function is applied using an Excel macro developed by Patrick Hester (UNC Ashville)[191]. To aid comprehension of the results and the logic they reflect, the next few paragraphs contain a step-by-step description of how it works.

First, recall that all λ takes on a value of 5. Each value of *x* is the result of λ on the movement from timestamp 0 to 1, and so on. Therefore each value of *e* depends on the relationship between nodes according to the effect of λ at each timestamp. The following simple simulation illustrates the methodology. Three components, *A*, *B*, and *C*, are in a relationship, where *A* decreases *B* and increases *C*, *B* increases *A* and *C*, and *C* decreases *A* and increases *C*.

[190] Salvador Bueno and Jose L. Salmeron, "Benchmarking Main Activation Functions in Fuzzy Cognitive Maps," *Expert Systems with Applications* 36, no. 3 (2009): 5223.
[191] The macro was first introduced in a series of conference papers, particularly Patrick Hester, "Analyzing Stakeholders Using Fuzzy Cognitive Mapping," *Procedia Computer Science* 61 (2015): 92-97.

Figure 4.5: FCM Example

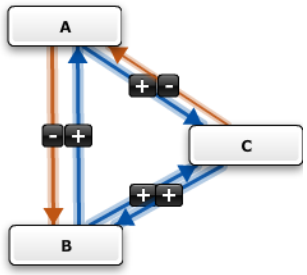
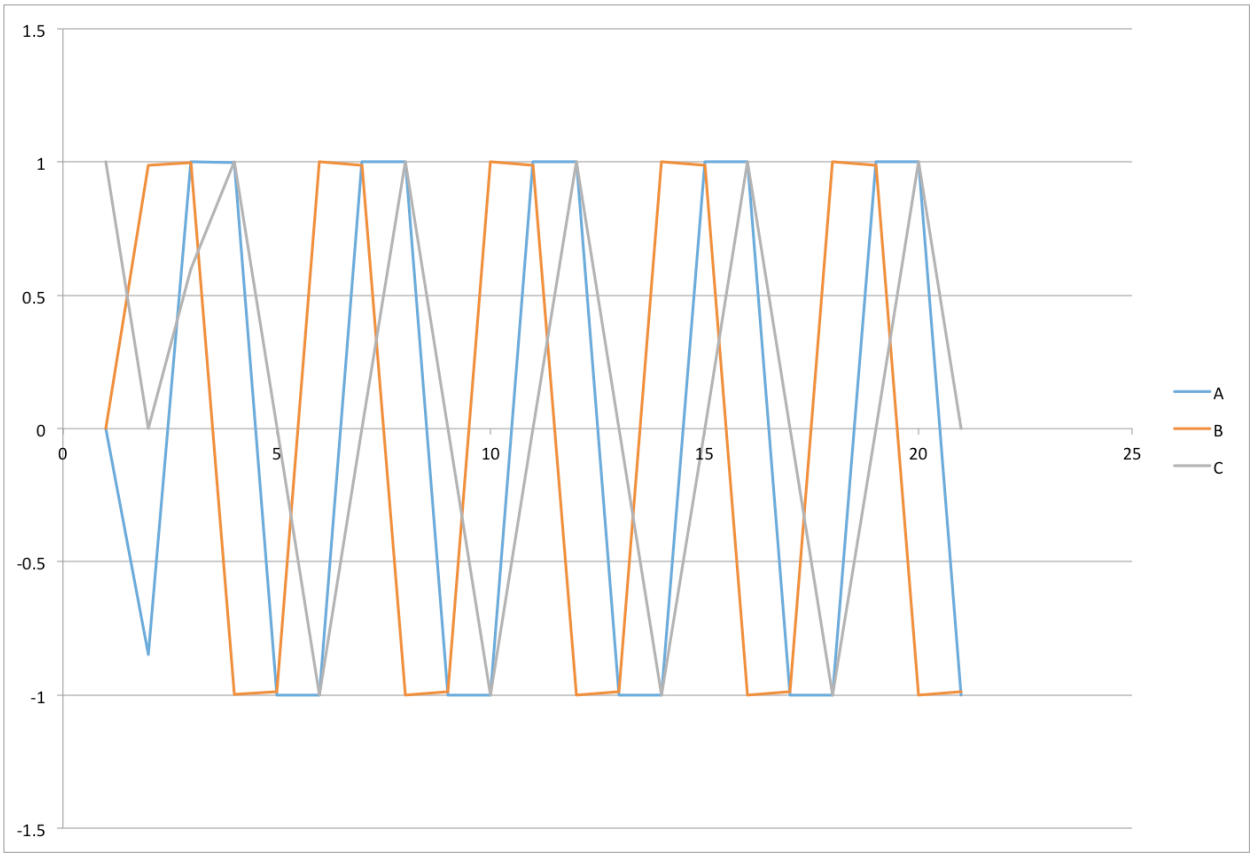


Table 4.3: FCM Example Matrix

	A	B	C
A	0	-1	1
B	1	0	1
C	-0.25	0.5	0

In this scenario, I set *C* to an initial value of 1, apply the sigmoid transfer function, set λ to 5, and run the simulation for 20 timestamps. Therefore, *C* represents a non-permanent change within this hypothetical simple scenario.

Figure 4.6: FCM Example Scenario 1 Results



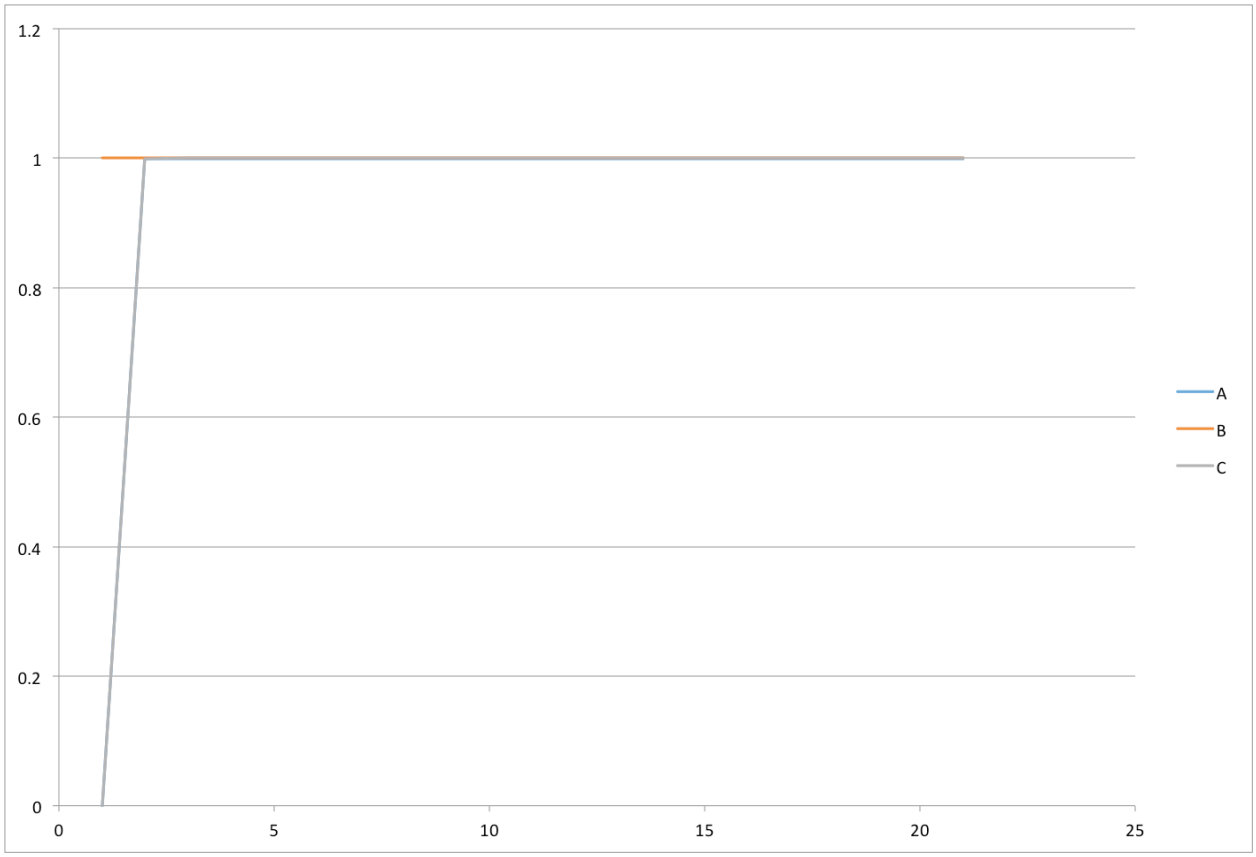
In this scenario two things are apparent. First, this simulation never reaches equilibrium. There is periodic behavior, placing it within the complex domain.[192] Second, initially setting *C* to 1 causes an immediate and dramatic decrease in *A* and an even more dramatic increase in *B*. Starting at about timestamp 5, a recurring pattern emerges, where *B* increases, followed by an increase in *A* and a simultaneous decrease in *B*, followed by an increase in *C* and a simultaneous decrease in *A*, and finally a decrease in *C*. in this scenario, setting *C* to 1 initially indicates that there would be cyclical behavior.

[192] For more on problem domains, refer back to the first section in this chapter.

The cyclical behavior follows from the logic of the causal relationships identified in the map. A high initial value of *C* exerts a causal effect on both *A* and *B*, pulling both up. However, for *A* this is dampened by the negative effect of *B* on *A*. As the relationship between these causal factors settles into a periodic cycle, we see a repeated pattern in which equilibrium is elusive.

A second example scenario is run where *B* is clamped to 1. Equilibrium in this second scenario is reached immediately, showing a maximum increase in all three nodes.

Figure 4.7: FCM Example Scenario 2 Results



Finally, FCMs are dynamic and deterministic. They are dynamic in that behavior changes over time. They are deterministic in that initial values determine output. With the continuous

FCM (sigmoid function), there are potentially infinite end states, meaning continuous FCMs can show chaotic results.[193]

4.2 Problem Structuring

Jetter and Kok propose a six-step framework for FCM mapping. This includes: 1) Project objectives and information needs clarification, 2) knowledge elicitation plans, 3) knowledge capture, 4) FCM calibration, 5) FCM testing, and 6) interpretation and use of model.[194]

The first step is the problem articulation.[195] Sterman argues this is the most important step in modeling the problem.[196] Useful models, while representing the real world, are models of the problem, not the system.[197] The reason I model the problem and not the system is because the model's purpose is to address a problem in a simplified way that exists in a real-world system.[198] This harkens back to avoiding the Type III error. Wooley and Pidd argue the importance of problem structuring, writing, "the process of arriving at a sufficient understanding of the components of a particular problem to proceed to some sort of useful operational research work."[199] In other words, problem structuring helps uncover the actual problem rather than relying on initial assumptions about the problem. This step also necessitates some accounting for time (i.e., on what time scale does the model operate?).[200]

---

[193] Hester and Adams, 110-111.
[194] Antonie Jetter and Kasper Kok, "Fuzzy Cognitive Maps for Futures Studies—A Methodological Assessment of Concepts and Methods," *Futures* 61 (2014): 48.
[195] Hester and Adams, 112.
[196] John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World* (Boston: McGraw-Hill Higher Education, 2000), 89.
[197] Sterman, 90.
[198] Hester and Adams, 112.
[199] R. N. Woolley, and M. Pidd, "Problem Structuring -- A Literature Review," *The Journal of the Operational Research Society* 32, no. 3 (1981): 198.
[200] Hester and Adams, 112.

Step two addresses sources of knowledge. Jetter and Kok identify three: the modeler, experts via survey, and from documents (e.g., scientific journals, reports, and newspaper sources). They furthermore note these methods can be combined.[201] This allows for expert participation in both knowledge elicitation and ensuring the problem is properly structured to help avoid making the Type III error.[202] These open sources are identified in subsequent chapters.

Step three is the actual collection of knowledge. Hester and Adams note that experts and stakeholders should note this is a *causal* and not a *correlation* map.[203] Additionally, once causation (e.g. "a change in A causes a change in B") is identified between concepts, the proper weights can be assigned to the causal link. This is accomplished using a Likert-type scale where weights are qualified rather than absolute.

Table 4.4: Sample Weight Scale (Adapted from Likert)[204]

Qualitative rating	Associated weight
Very strong positive	1
Strong positive	0.75
Medium positive	0.5
Weak positive	0.25
No effect	0
Weak negative	-0.25
Medium negative	-0.5
Strong negative	-0.75
Very strong negative	-1

[201] Jetter and Kok, 49.
[202] Hester and Adams, 113.
[203] Hester and Adams, 114.
[204] Rensis Likert, "A Technique for the Measurement of Attitudes," *Archives of Psychology* 22, no. 140 (1932): 55.

This helps for two reasons. First, it generalizes the model so that experts, stakeholders, and observers can better understand cause and effect. Second, it simplifies the potentially infinite values the weights can take, as identified in the discussion about the sigmoid function. Participants will not need to argue over the exact weight, but rather a limited number of qualified weights.

The fourth step is calibrating the FCM once it has been constructed in step three. This allows the modeler to see if the simulation behaves as expected. The fifth step is testing. Sterman notes this is not validation in the strictest sense because "All models are wrong, so no models are valid or verifiable in the sense of understanding the truth." He adds, "The question facing clients and modelers is never whether a model is true but whether it is useful."[205] Therefore, the goal is simply to test whether or not it acts as expected. Hester and Adams note this is ultimately subjective.[206] In the subsequent problems this stability test is performed without claiming to solve the problem.

The sixth step is the exploration of the model's parameters. Hester and Adams refer to this as "speculative, *what-if* scenarios."[207] For example, the modeler can ask what would happen if a concept were clamped to a specific value. That is, the modeler can "play God" with feasible system changes. Clamping "is not a one-time impulse …, but a change that lasts over extended periods of time."[208] This can be illustrated with the following example: In a fictitious model of the disarmament problem, the researcher can clamp the value of the authority of the International Atomic Energy Agency (IAEA) to +1. When running the scenario, linked concepts will affect

---

[205] Sterman, 890.
[206] Hester and Adams, 117.
[207] Hester and Adams, 117.
[208] Antonie Jetter and Willi Schweinfort, "Building Scenarios with Fuzzy Cognitive Maps: An Exploratory Study of Solar Energy," *Futures* 43, no. 1 (2011): 55.

each other depending on direction and weight of the links; however, at each step in the simulation, the IAEA's authority will not be undermined by changes to the system. In this hypothetical scenario, if all states surrendered sovereignty over nuclear weapons to the IAEA, then, depending on how the rest of the model's parameters were set up, the value of nuclear weapons might collapse to zero.

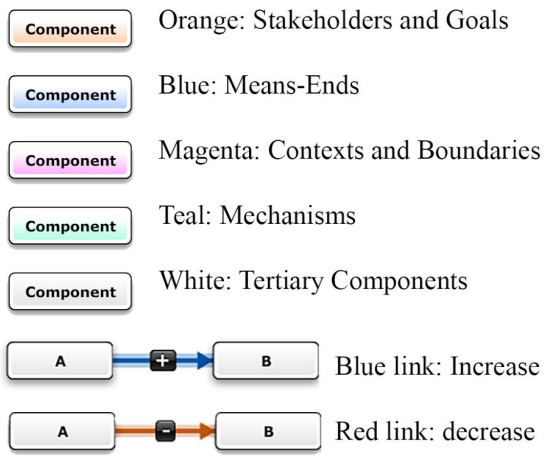
Finally, FCMs can be constructed by hand, in spreadsheets, in Photoshop, or in computational modeling and simulation software, such as Gephi,[209] or Mental Modeler. Mental Modeler is a FCM analysis tool that allows researchers the ability to explore environmental, social, or other issues. It utilizes user-defined components within a system, user-defined relationships between components, and user-run "what if" scenarios. Users can then determine how the system as a whole is affected by feasible tweaks to specific variables within the system.[210]

Applying FCM to this research, after examining two related problems that upset efforts towards global nuclear disarmament, I recreate the parameters of these real-world problems. This process requires several steps. First, I identify each problem's stakeholders and stakeholder goals. Stakeholders are groups with vested interest in the outcome of the problem. This includes states, civilian firms, nonprofit organizations, religious groups, and others. Power to control the outcome of the problems' solutions is not spread equally, nor does one stakeholder hold an absolute monopoly of power. This step is represented by "Who?" The second step is to clearly identify and articulate the problems and to break them down into their basic elements. This includes identifying the problems' objective narratives, objective hierarchy networks, and the

[209] Gephi is a network analysis tool, usually to explore social networks, using graph theory. Its applicability to FCMs requires tweaking the purpose of the software to some degree.
[210] Steven Gray, "Mental Modeler," http://www.mentalmodeler.org/.

means-ends networks. This step is represented by “What?” The third step identifies substantive information, or the motivational forces behind the problems and actions. This step is represented by “Why?” The fourth step is to refine the problem by identifying the context and problem boundaries. This step is represented by “Where?” The fifth step is to identify the mechanisms by which stakeholders can move from the current state (the problem) to an idealized state (a solution). This step is represented by “How?” The final step is to assess the appropriate timeframe for problem interaction. This step is represented by “When?” Before progressing to the final stage of modeling, in order to test problem stability, hypothetical scenarios are run that do not necessarily indicate a viable path towards synthesis; rather, this stage is merely to ensure there is no chaotic behavior. Once the problems have been constructed using these six steps, the model progresses by merging the two problems together and restructuring to ensure nuclear weapons interact with the problems as they would in the real world. This final structuring creates the “mess,” or the complex interaction between problems. Components and links are color coded according to the following scheme illustrated in Figure 4.8.

Figure 4.8: FCM Color Code



This simulation is deterministic. It utilizes cause and effect to determine the outcome along [-1, 1]. Incorporating the Likert-type Scale for outcome, final variable states of -1 indicate a maximum decrease. For example, in a hypothetical if maximizing cooperation causes sovereignty to take on a final value of -1, then maximizing cooperation decreases sovereignty to the maximum degree. Negative values other than -1 are scored according the Likert-type Scale. Final variable states of 1 indicate a maximum increase. Final variable states of 0 indicate no change. In other words, 0 indicates the status quo.

Using the FCM framework, I identify the problems' elements as noted above and apply the Likert-type Scale to show interaction and weights between nodes. I accomplish this using Mental Modeler, an online FCM tool, described above. I run several "what if" scenarios using Hester's PC-based Excel scenario tool that allows users to design scenarios using the following criteria: transfer type from one timestamp to the next (identified above as binary, trivalent, and sigmoid), the specification of λ (which is set to 5, according to the explanation above by Bueno and Salmeron), the number of timestamps to run (ranging from 1 to ∞), and the independent variables. Because I am using the Likert-type Scale to indicate the weight of node links, I am using the sigmoid transfer function.

Independent variation is further controlled by two mechanisms. First, the user can choose an initial value for a variable to take along [-1, 1]. This simulates a one-time change in value. For example, the signing of an international agreement maximizes cooperation for a single timestamp only; in other words, cooperation once does not compel further cooperation within the model. Signing one treaty does not mean all future treaties are signed. Take note that setting the initial value of an independent variable means it will revert to a dependent variable following the

first timestamp. The second way the user can control independent variation is to "clamp" the value of a variable to a number along [-1, 1], as noted earlier. For example, a successful disarmament treaty will not replace sovereignty with something else. Therefore, it could be useful to clamp sovereignty to zero. Unless otherwise indicated by setting initial values or clamping independent variables, all dependent variables will begin at timestamp 0 with an initial value of 0. In other words, 0 is the status quo that varies according to weights within the model and user-defined, feasible changes.

4.3 Summary

This chapter outlines fuzzy cognitive mapping methodology as well as its mathematical underpinnings. It then creates an example model and runs various scenarios in order to illustrate how problem resolution can be attempted using fuzzy cognitive mapping. Finally, it addresses problem structuring and how to apply fuzzy cognitive mapping to the problems identified in the following chapters.

CHAPTER 5

PROBLEM 1

Nuclear-armed states are resistant to disarmament, while significant portions of the world desire a nuclear-free international system.

5.1 Problem 1 Articulation

Ultimately, the disarmament problem is one with no formal solution. To illustrate this problem, Lewis F. Richardson's arms race model[211] reveals that, by diminishing positive numbered nuclear redundancies, arms races cannot be worked backwards to reach zero. Rather, models can only approach zero. On the other hand, the model is likely to stop at 1 per side; if the referent object is a warhead, then there is no such thing as a partial warhead, for the purpose of disarmament. Therefore, at best, arms control proponents can only mathematically work back to a non-zero whole number.[212] This is also illustrated by Fry's model, where—in uncomplicated terms—State A's military spending S_A is a function of State B's military spending S_B:

$$S_A = f(S_B)$$

In Fry's arms race, each side's military spending is determined by the other side's military spending in an effort to reach capability equilibrium. Neither side desires being less battlefield-ready than their respective adversary. Financial transactions for weapons, however, are not crucial, but Fry's model shows the realist logic that should prevent disarmament. To put

[211] Lewis F. Richardson, *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War*, ed. Nicolas Rashevsky and Ernesto Trucco (Literary Licensing, LLC, 2012).
[212] Of course, it is within the realm of possibilities that introducing an unforeseen delta or random variation can collapse Fry's model to 0.

this in more relevant terms, "great powers always counter the weapons of other great powers, usually by imitating those who have introduced new weapons,"[213] and the fact that one bomb exists means that two bombs must exist at a minimum.

Therefore, this modeling does not attempt to show how nuclear redundancies can diminish to zero; rather, it tries to synthesize international realities and desired end states, where nuclear weapons no longer serve deterrence functions, and where, to borrow from John Mueller, nuclear weapons are essentially irrelevant. Mueller argues that Cold War relative peace has created a pattern where it is now assumed major war is not within the set of potential future outcomes; therefore, mutual assured destruction (MAD) and nuclear weapon utility has atrophied out of boredom.[214] At this point, disarmament becomes possible. Mueller's optimism during the waning Cold War years has not born fruit, but that does not imply that his conclusion is incorrect. Rather, it might simply mean his conclusion needs some tweaking to account for changes in the international system since 1988. Therefore, this project will attempt to account for present-day structural theories, particularly those that gave rise to Mueller's unfulfilled prophesy—namely realism.

Given presently understood physics, chemistry, and technological capabilities, there is a limit to balancing where equilibrium is certain—MAD. Nuclear weapons' destructiveness signals to adversaries the state's capabilities in no uncertain terms. There is no more perfect weapon for reaching equilibrium than the atomic weapon.

There is a caveat that must be addressed, however. The ultimate weapon in this regard can only order the international environment given that two adversaries have weapon systems that can survive a first strike. For the purpose of Problem 1, MAD through symmetry stabilizes

---

[213] Waltz, (1981): 7.
[214] Mueller, 56.

the system because no side can survive a nuclear war, and the threat of nuclear war diminishes incentives to engage in even conventional wars, out of the fear of escalation. Furthermore, Brodie sums up the relationship between second-strike capabilities and security: "Stability is achieved when each nation believes that the strategic advantage of striking first is overshadowed by the tremendous cost of doing so."[215] The ability to return fire is crucial in this calculus. Schelling agrees that stability and equilibrium are reached given two variables: First, both sides must be able to obliterate the other, and second, both sides' retaliatory capabilities must be strong enough to survive a first strike.[216] In the age of nuclear triads, where second-strike capabilities are guaranteed through land-based intercontinental ballistic missiles (ICBMs), strategic bombers, and submarine-launched ballistic missiles (SLBMs), realist theory suggests equilibrium has been reached between much of the nuclear-armed world.[217] MAD's stability is so compelling that some scholars prescribe *more* proliferation to prevent any future wars.[218]

Both Brodie and Schelling explain stability in a bipolar world (i.e., the Cold War) in terms of absolute symmetry. The balance of power (BOP) must account for proliferation decisions in addition to the maintenance of nuclear weapons programs. That is, if State A proliferates, and if State B does not balance, the states are in an asymmetrical relationship and are thus not in equilibrium. If State B does not have security guarantees by another nuclear

---

[215] Brodie, 303.
[216] Thomas C. Schelling, "Surprise Attack and Disarmament," *Bulletin of the Atomic Scientists* 15, no. 10 (December 1959): 414.
[217] China, India, Russia, and the US have nuclear triads. Roughly 99% of the world's nuclear weapons in 2018 fall under triad systems. There is some additional evidence Israel also enjoys a nuclear triad. See Ewan W. Anderson, Liam D. Anderson, and Ian Cool, *An Atlas of Middle Eastern Affairs* [e-book], Second ed., (London: Taylor & Francis Group, 2014): 233.
[218] Waltz (1981), and John J. Mearsheimer, "Back to the Future: Instability in Europe after the Cold War," *International Security* 15, no. 1 (1990): 5-56.

power, then State A may pose an existential threat to State B. Erickson adds that without such guarantees, State B is willing to suffer proliferation costs to bring it back into equilibrium.[219]

Waltz argues that gradual proliferation occurs because the ability to annihilate the other offers deterrence and peace assurance.[220] Schelling agrees, arguing that even limited wars are unlikely because small wars can escalate to major wars, and major wars can escalate to nuclear wars.[221] In this sense if two sides come to the brink of even a limited war, both sides have more to gain by conceding than they do by moving forward with war, especially if potential gains from winning the war are minor. Waltz further argues that even if great powers do come to militarized conflict the war will be limited because neither side can gain advantage over the other without risking nuclear war.[222]

Steven Pinker—not writing explicitly about nuclear deterrence and proliferation—highlights deterrence succinctly. He writes,

> "A credible deterrence policy can remove a competitor's incentive to invade for gain, since the cost imposed on him by retaliation would cancel out the anticipated spoils. And it removes his incentive to invade from fear, because of your commitment not to strike first and, more importantly, because of your reduced incentive to strike first, since deterrence reduces the need for preemption."[223]

---

[219] Stanley A. Erickson, "Economic and technological trends affecting nuclear nonproliferation," *The Nonproliferation Review* 8, no. 2 (2001): 42.
[220] Kenneth N. Waltz, "Nuclear Myths and Political Realities," *American Political Science Review* 84, no. 3 (1990): 734.
[221] Schelling (1966), 105.
[222] Waltz (1981), 5.
[223] Steven Pinker, *The Better Angels of Our Nature: Why Violence Has Declined* (New York: Penguin Publishing Group). Kindle Edition: 34.

In addition to Waltz's argument that "More may be better," de Mesquita and Riker support this conclusion, writing, "Once half the nations in the system have nuclear weapons, the number of possible nuclear attacks diminishes, going to zero when all countries have sufficient capabilities to deter their relevant adversaries."[224] Mearsheimer furthermore makes blanket, normative arguments for horizontal proliferation,[225] as well as individual arguments that Ukraine and Japan should enjoy nuclear deterrents.[226] Sagan calls this approach "proliferation positive." Although critical of "proliferation positive" approaches, Sagan notes that it "flows easily from the logic of rational deterrence theory."[227]

Taking this to its resultant conclusion, even non-proliferated states with robust security guarantees by nuclear-armed states should be expected to proliferate on a long enough timeline. Because under realism alliances can change, states under nuclear umbrellas cannot be certain their guarantees will last; therefore, these states have incentive to proliferate to maximize their future expected payoff.[228]

Hymans sums up the realist position:

> [A]dopting the realist vision of international relations inexorably leads to the conclusion that all states that can go nuclear, should go nuclear—and the sooner, the better. If they have not done so yet, it is simply a matter of time before they do. The core realist prediction about proliferation is that some event will

---

[224] Bruce Bueno de Mesquita and William H. Riker, "An Assessment of the Merits of Selective Nuclear Proliferation," *Journal of Conflict Resolution* 26, no. 2 (1982): 287.
[225] Mearsheimer (1990), 20.
[226] John J. Mearsheimer, "The Case for a Ukrainian Nuclear Deterrent," *Foreign Affairs* 72, no. 3 (Summer 1993): 50-66, and John J. Mearsheimer, (radio interview, "Morning Edition," *National Public Radio*, June 21, 1993).
[227] Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate* (New York: W. W. Norton & Company, 1995), 45.
[228] For a discussion on realism and relative gains, see Robert Powell, "Absolute and Relative Gains in International Relations Theory," *The American Political Science Review* 85, no. 4 (1991): 1303-1320.

> inevitably come along—sooner rather than later—that finally causes the dam to break and the world to go nuclear.[229]

Not all who accept realist logic agree with its prescriptive argument, which opens up one contentious point in Problem 1. Reiss agrees that proliferation *will* happen, but he disagrees that it *should*. He writes, "in ways both fast and slow, we may very soon be approaching a nuclear 'tipping point,' where many countries may decide to acquire nuclear arsenals on short notice, thereby triggering a proliferation epidemic,"[230] adding, that the US should take a leading role in preventing proliferation.[231]

Additionally, Sagan's debate with Waltz offers some critiques of realists' "proliferation positive" arguments, adding an "alternative *theory* of the consequences of nuclear proliferation."[232] Sagan, a proponent of realism as formal logic but a defector from its normative conclusions, makes two broad critiques of horizontal proliferation. First, militaries, as essential and powerful components of the state, have shared preconceptions, rigid customs, and insular interests that could lead military leaders towards and beyond the nuclear brink. Second, many future proliferators might lack adequate civilian control over the military. Juntas are less likely to fear domestic unrest or coup, and are therefore more likely to eschew civilian concerns.[233] He

---

[229] Jacques E. C. Hymans, "THEORIES OF NUCLEAR PROLIFERATION: The State of the Field," *The Nonproliferation Review* 13, no. 3 (2006): 456.
[230] Mitchell B. Reiss, "The Nuclear Tipping Point: Prospects for a World of Many Nuclear Weapons States," in *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, ed. Kurt M. Campbell, Robert J. Einhorn, and Reiss B. Mitchell (Washington, DC: The Brookings Institution, 2004), 4.
[231] Reiss, 16.
[232] Sagan and Waltz, 48.
[233] Sagan and Waltz, 48-49.

furthermore argues that military culture and reputational pressures "to protect oneself" have prompted some military nuclear accidents.[234]

This research adopts realist logic in the same way that Sagan adopts it. Nuclear weapons pose enormous risk to the international system, despite their utility in promoting or maintaining non-belligerent relations. This form of realism accepts realism's underlying logic but also acknowledges that it cannot ignore other states' and non-state actors' existential concerns vis-à-vis the hazards of nuclear weapons by accidental or designed detonation. Nuclear abolitionists,[235] although holding a fraction of the vote held by nuclear states, still get a vote in Problem 1's resolution. Abolitionists' fears are implicitly articulated throughout this text; however, the driving problem in this "mess" is the tension between nuclear weapons states' desire for deterrence and abolitionists' desire for disarmament.

Abolitionists make several arguments for disarmament. First, the fate of the world should not be left up to the whims of a handful of states in conflict.[236] That is, a war between two great powers might not abide by sovereign borders, and nuclear war *will* affect non-belligerent states at the global level, as discussed in Chapter 2. Therefore, it is the responsibility, they argue, of nuclear weapons states to take disarmament negotiations seriously. Because of the risk to non-nuclear states, and despite a lack of power over nuclear weapons states, members of the non-

---

[234] Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, NJ: Princeton University Press, 1993), 251-262.
[235] For the purpose of this dissertation, the word "abolition" always refers to the complete and global elimination of nuclear weapons.
[236] Hector Guerra, "Ban the Bomb? A Mexican Response," *Bulletin Of The Atomic Scientists* 70, no. 6 (2014): 21.

aligned movement feel or have felt it is their duty and their right to take ownership of the problem.[237, 238]

Second, some actors see the possession of nuclear weapons through a lens of injustice. That is, nuclear weapons are an expression of primal strength that perpetuates inequality among nations.[239] In this sense these actors see nuclear weapons as an obstacle to issues of global justice. Dependence on the status quo means that perceptions of injustice are ignored. For example, boots on the ground during an annexation of a deterrent-less state's territory by a superpower means no other superpower can enact justice on behalf of the victim state. Diplomacy might not persuade the aggressor to back down if its deterrent capabilities give it no reason to back down, and deterrence means military action is unwise. It is therefore reasonable for small states to call for abolition along these lines.

Third, Wheeler argues the deterrent assumption of realism is not a permanent fixture in international order. Rather order is a function of trust building.[240] This complements the second argument. Expressly, reliance on deterrence diminishes the utility for nuclear-armed states to engage in trust-building exercises. Here, Wheeler appears to be taking the "utopian realism" approach, which accepts the balance of power but argues that norms change through an iterative process whereby states seek to mitigate anarchy by slowly evolving towards some nondescript goal of global peace. In other words, conflict might not be a rational choice in a future global

---

[237] Lorenz Lüthi, "The Non-Aligned Movement and the Cold War, 1961-1973," *Journal of Cold War Studies* 18, no. 4 (2016): 98.
[238] However, Problem 1's true owner, as identified later in the model, is the nuclear weapon state.
[239] Ray Acheson, "Foregrounding Justice in Nuclear Disarmament: A Practitioner Commentary," *Global Policy* 7, no. 3 (2016): 407.
[240] Nicholas J. Wheeler, "Beyond Waltz's Nuclear World: More Trust May Be Better," *International Relations* 23, no. 3 (2009): 428.

community of communities.[241] Neither Wheeler nor Booth takes the position that international politics has reached an endpoint where conflict is unacceptable; rather, they take issue with realist arguments that disarmament is a "fictional utopia," and they argue that human agency and free will give decision makers the ability to change the system for a better. Therefore, a world without nuclear weapons is not unthinkable, and it is a world for which nuclear weapon states should work through an iterative process of gradual disarmament.[242]

Fourth, Müller envisions a *stable* world without nuclear weapons. That is, a future state of global zero will most likely reflect cultural norms that make nuclear possession untenable. He sees this future very clearly as evidenced by today. Our abhorrence of nuclear weapons and fear of their effects today reside in a space also occupied by stability through deterrence. But through a social process already in motion, the weight of our abhorrence and fear, as well as the nuclear neglect and disinterest, will continuously reduce nuclear weapons' roles to an ever-diminishing speck until they no longer serve any useful purpose. Because this is a likely outcome on a long enough timeline, Müller writes, it is important to continue working towards this end goal.[243]

The last arguments from abolitionists include the assertion that possessing nuclear weapons is inherently immoral, that they are unable to place trust in irrational leaders following the realist assumptions of deterrence, that there is a high risk of nuclear accidents, and, quite simply, that the costs of building and maintaining nuclear weapons is exorbitant.[244] One way to phrase this is if moral arguments and extraordinary risks will not persuade states to give up their

---

[241] Booth, 527-45.
[242] Wheeler and Booth, 54.
[243] Harald Müller, "Out of the box: Nuclear disarmament and cultural change," in *Stable Nuclear Zero: The vision and its implications for disarmament policy*, ed. Sverre Lodgaard (New York, New York: Routledge Global Security Studies, 2017), 69-70.
[244] Anne I. Harrington, Eliza Gheorghe, and Anya Loukianova Fink, "What Arguments Motivate Citizens to Demand Nuclear Disarmament?" *Bulletin Of The Atomic Scientists* 73, no. 4 (2017): 255.

nuclear arsenals, then perhaps the best argument is that nuclear weapons programs hit states where it hurts the most—their wallets.[245]

These divergent arguments—with realists and nuclear weapons states on the one hand and abolitionists on the other—exposes a dialectic, which is the fundamental basis of the problem. Although some actors have significantly more power than other actors, both powerful and less-powerful actors are presently engaged in a conversation about the utility of possessing nuclear weapons. Neither camp desires to back down, which means the problem cannot be solved simply, but nevertheless they are willing to participate in the discussion. In other words, it appears satisficing is possible. Therefore, in the following sections the problem's stakeholders, components, boundaries, operating means, and timing are identified, discussed, and modeled using Fuzzy Cognitive Mapping.

5.2 Problem 1: Who?

Central to the nuclear weapons "mess" and its constituent problems are stakeholders. These are actors that have some level of influence over behavior, whether strong, weak or in between, and have interest in the outcome of decisions. Pokras adds that "Effective problem solving ensures that all necessary stakeholder viewpoints are considered or represented during discussions. The best insurance to finding the right solution and guaranteeing buy-in to its implementation is to widen the view of a problem at the beginning."[246] With the proliferation problem, there are certainly going to be divergent viewpoints, but, as will be demonstrated

[245] On the other hand, the role economics plays in decisions to proliferate or not do not appear to be decisive. See Erwin Häckel, "Towards non-nuclear security: costs, benefits, requisites," in *Security Without Nuclear Weapons: Different Perspectives on Non-Nuclear Security*, ed. Regina Cowen Karp (New York: Oxford University Press, 1992), 78.
[246] Sandy Pokras, *Team Problem Solving: Reaching Decisions Systematically*, Rev. ed., Fifty-Minute Series (Menlo Park, CA: Crisp Publications, 1994), 28.

below, these different viewpoints' inclusion in the model is necessary. If the needs of some stakeholders are overlooked, these stakeholders can simply walk away from the discussion. If a nuclear-armed state walks away, then there is no hope for the pro-disarmament camp.

This section has six steps. First, identify stakeholders. Second, classify stakeholders. Third, evaluate stakeholder attitudes. Fourth, map out stakeholders. Fifth, identify stakeholder engagement priorities. Sixth, develop a stakeholder management plan.[247]

Identify Stakeholders

Because nuclear weapons pose global threats, there are—at the time of this writing—potentially 7.5 billion stakeholders. Even scientists on long-term assignment aboard the International Space Station or at the Amundsen–Scott South Pole Station have some level of interest in nuclear weapons, but they have little power to change the system. In other words, the list of stakeholders can be quite long. For the purpose of this research, however, stakeholders will include actors with some noticeable power to make changes to the system. Table 5.1 identifies seven groups of stakeholders as relevant to the mess and its constituent problems.

Each stakeholder has various wants. These are identified in Table 5.2. For the purpose of this research, wants will be pared down to the ultimate goal; secondary and tertiary goals will become self-evident and will be included in the model during later modeling. Ultimately, nuclear weapons serve states' security goals, if only under different names (e.g., deterrence for the US, *grandeur* for France). Other stakeholder wants vary accordingly.

[247] Adapted from Hester and Adams, 133.

Table 5.1: Problem 1 Stakeholders

Stakeholder	Description
1. NWs states	Nuclear-armed states as unitary actors
2. Production Firms	In the case of the US these are three private US for-profit corporations that build, house, and manage US nuclear warheads. These include AECOM and Betchtel, BWX Technologies, and Honeywell. Beyond the US, these include component manufacturers, raw materials extractors, etc. These production firms are furthermore influenced by stockholders.
3. International verification and compliance agencies	These are international organizations that encourage peaceful use of nuclear materials, administer safeguards to ensure compliance, and work to prevent nuclear proliferation (for example, the IAEA).
4. NGOs and activists	These are groups of civilians that actively promote nonproliferation and disarmament (examples include ICAN, Greenpeace, etc.).
5. Media	These are groups or individuals that spread information through various communication methods (e.g., television, radio, print, social media).
6. NPT states	These are signatory states in good standing in accordance with the NPT, which includes most recognized states not previously identified as nuclear weapons states[248] and major UN voting blocs, such as the non-aligned movement[249].
7. Religious leaders	These are influential individuals of various faiths that can sway public opinion from the pulpit.

The nuclear-armed states above all require some form of security, and they believe nuclear weapons serve that goal. While the US and, to a lesser extent, the UK view security through a deterrent lens against Russia, during the Cold War the Soviet Union's nuclear weapons program was not necessarily developed for traditional deterrence, but rather to balance against coercive US foreign policy.[250] France, while even less concerned about deterring Russia, views its nuclear weapons program as a means by which to ensure its territorial integrity and, more

[248] At the time of writing, South Sudan is the only non-signatory and non-nuclear weapons state.
[249] Excluding Pakistan, India, and North Korea (as members of NAM), as well as China (as an observer state). These are nuclear weapons states.
[250] Cowen Karp, 9.

Table 5.2: Problem 1 Stakeholder Wants

Stakeholder	**Want**
NWs states	Security
Production Firms	Maximize profits
International verification and compliance agencies	Abolition
NGOs and activists	Abolition
Media	Stories that sell
NPT states	Abolition
Religious leaders	Abolition[251]

importantly for the French, a means by which to maximize its position as a world power.[252] Israel, on the other hand, completely views its nuclear weapons program as a mechanism for deterring conventional war and Arab proliferation, in addition to being the ultimate guarantor of its survival.[253] In very much the same vein, the DPRK's nuclear weapons program serves to ensure its very existence. The lesson from the Korean War is that the North's international legitimacy is not certain. Because of this, The DPRK's official position is that of deterrence against the US and Asian forces, and it views thermonuclear devices and ICBMs as guarantors of Kim's survival.[254] Pakistan and India, while adversarial, do not share the same existential threat

[251] *Most* religious leaders call for abolition; however, some, as identified in the following text, do not call for abolition and might even call for nuclear attack.
[252] Klaus Schubert, "France," in *Security with Nuclear Weapons?: Different Perspectives on National Security*, ed. Regina Cowen Karp (New York: Oxford University Press, 1991), 162-163.
[253] Nuclear weapons' ultimate role are to provide Israel with a "Samson option," where, rather than allowing military conquest of Israel by Arab armies, Israel can destroy itself in order to destroy its enemies. Seymour M. Hersh, *The Samson Option: Israel's Nuclear Arsenal and American Foreign Policy*, 1st ed. (New York: Random House, 1991), 137-138.
[254] While writing this in spring and summer 2018, significant positive events occurred between the DPRK, the ROK, and the US that might change this model's calculus. Continued monitoring is necessary.

that The DPRK and Israel face. Pakistan and India seek to balance against each other (India's calculus is more complex, including a "threat of a USA-Pakistan-China axis"[255]). The creation of Pakistan and India exposed contested territorial divisions and has resulted in armed combat to settle these divisions. Nuclear weapons, therefore, seek to prevent territorial loss on either side of the borders.

Although holding varying degrees of power and capability, nuclear weapons states are viewed in this literature through a realist lens. Keohane does not necessarily subscribe to realism, but he succinctly defines states as structural realists see them:

> [S]tates [are] unitary rational actors, carefully calculating costs of alternative courses of action and seeking to maximize their expected utility, although doing so under the conditions of uncertainty and without necessarily having sufficient information about alternatives or resources to conduct a full review of all possible courses of action.[256]

The word "unitary" here is a key defining term. Anarchy implies the sameness of states;[257] therefore, there is no need to differentiate all nine nuclear weapons states as individual units of analysis. For the purpose of abiding by the foundational tenets of realism, the only necessary distinction between states is whether or not they possess nuclear weapons. How or why they proliferated or not is only of secondary or tertiary concern. Once nuclear weapons come into possession, the weapons between states share a common goal: Security. This point is crucial and

---

[255] Achin Vanaik and Praful Bidwai, "India and Pakistan," in *Security with Nuclear Weapons?: Different Perspectives on National Security*, ed. Regina Cowen Karp (New York: Oxford University Press, 1991), 258.
[256] Robert O. Keohane, "Theory of World Politics: Structural Realism and Beyond," in *Neorealism and Its Critics*, ed. Robert O. Keohane (New York: Columbia University Press, 1986), 165.
[257] Kenneth N. Waltz, "Political Structures," in *Neorealism and Its Critics*, ed. Robert O. Keohane (New York: Columbia University Press, 1986), 87.

must be driven home. Because unilateral disarmament in no way maximizes expected utility and instead undermines security needs, there is no difference between the goals of the US and those of the DPRK or any other state. On the other hand, this research does not discount very real and perceptible differences between states in terms of power and capability. These distinctions, however, are more suited for Problem 2.

As identified earlier, the US is possibly the only state that privatizes the construction, housing, maintenance, and management of its nuclear arsenal. In this text these organizations are referred to as production firms. AECOM and Bechtel (NYSE:ACM), an engineering firm, holds contracts to two of the National Nuclear Security Administration's (NNSA) nuclear stockpile laboratories. Honeywell Federal Manufacturing and Technologies (NYSE:HON) manages the third NNSA laboratory. BWX Technologies (NYSE:BWXT) holds a contract for nuclear weapons component manufacturing. These corporations seek to maximize their profits, may or may not be publicly traded, and answer to a set of shareholders (or profit-seekers in cases where there is no public sale of stocks) that, in turn, seek to maximize profits. Other states', although not as explicit as the US also employ some kind of civilian labor upstream and downstream of finished nuclear warheads.

International verification and compliance agencies are intergovernmental organizations that seek to ensure that member states of the UN are good stewards of nuclear energy programs in accordance with the NPT. Ultimately, these organizations seek abolition,[258] but other

[258] As will be discussed later, NPT Article VI calls for the eventual global elimination of nuclear weapons and for nuclear weapon states to take steps towards abolition in "good faith." United Nations, Office of Public Information, *Treaty on the Non-proliferation of Nuclear Weapons. United Nations*, Office of Public Information, United Nations Publication OPI/372 (New York, 1969).

secondary or tertiary goals are more at the forefront of their work, due to secondary and tertiary goals being easier to reach. For example, the IAEA's mission is to

> Accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.[259]

The IAEA, situated in Vienna, Austria, operates through member states. The US, for example, supports the IAEA through the Department of Energy, and support is provided through various national laboratories, one of which states on its website, "The IAEA faces many challenges such as essentially flat budgets, increasing work load as more nuclear facilities come on-line, greater reliance on safeguards information and advanced technologies, and increased effort to detect undeclared nuclear activities and procurement networks."[260] In other words, international verification and compliance agencies depend on the state for mission resources, and their ability to ensure compliance is diminished as more nuclear energy reactors, uranium enrichment facilities, and fissile materials sites are constructed, and clandestine programs are created.

Nongovernmental Organizations (NGOs) and activists are groups or individuals that collectively advocate for the total elimination of nuclear weapons. While these groups are represented as a single unit with a unified stance against nuclear weapons, the text must reflect other divergent goals. The International Campaign to Abolish Nuclear Weapons (ICAN) takes no position against peaceful nuclear energy programs; however, Greenpeace, an abolitionist, environmental group that protested nuclear testing due to its degradation of the environment,

---

[259] "Statute," Article II, *International Atomic Energy Agency* (Vienna, Austria, December 1989), 5.

[260] "Nonproliferation Policy and Implementation Group," Brookhaven National Laboratory. https://www.bnl.gov/NNS/policy.php.

believes "Nuclear power is part of the poblem," due to the risk of nuclear reactor meltdown.[261] Still, because this research focuses on the primary goal, these divergences will be identified only when necessary.

The Media is a collective group of reporters that seeks to find stories that sell. These include legitimate journalists reporting through television, radio, newspapers, or social media. This group also includes hobby journalists that report through social media, blog posts, or Internet videos. Many in this latter group do not get paid for their efforts; however, they "sell" their stories for clicks or to build their Internet profile.

For the purpose of this research NPT states are defined as non-nuclear weapons states that are in good standing with the NPT and seek to uphold the NPT's three pillar mission: non-proliferation, disarmament, and peaceful use of nuclear technologies. This includes most of Europe, all of South America, all of Africa (except South Sudan), much of Asia, and all of Oceania. NPT states make up a major voting bloc in the UN; however, the normative values of the NPT do not necessarily translate to NPT states voting behaviors. While 190 states are member to the NPT, including a handful of nuclear-armed states, only 122 states voted in favor of the Treaty on the Prohibition of Nuclear Weapons. Most of the rest of NPT states failed to cast a vote. The Netherlands, while a party to the NPT, cast a no vote. For the purpose of this project, NPT states are abolitionists. Variance from this position will be identified when and if necessary.[262]

Religious leaders include figures, such as the Pope, the Dalai Lama, and charismatic Jewish, Islamic, and spiritual leaders. This list also includes leaders such as Billy Graham (d.

---

[261] "Nuclear power is part of the problem," Greenpeace, last modified July 1, 2016. https://www.greenpeace.org/archive-international/en/campaigns/climate-change/Solutions/Reject-false-solutions/No-to-nuclear/.

[262] "When and if" because this model will change as social and political realities change.

2018), Deepak Chopra, Thich Nhat Hanh, Sri Sri Ravi Shankar, and L. Ron Hubbard (d. 1986), whose writings presently influence social beliefs and behaviors (despite whether or not those figures are presently living). Here, religious leaders stand against weapons that can usher in Armageddon. They are abolitionists because that is the dominant position. However, some religious leaders endorse using nuclear weapons. For example, during summer 2017 after US President Donald Trump called for "fire and fury" against the DPRK, Trump's friend and Evangelical Southern Baptist pastor Robert Jeffress said Donald Trump had been given divine sanction to kill DPRK leader Kim Jong Un using any means necessary. Speaking to the *Washington Post*, he suggested this God-ordained green light included using nuclear weapons against North Korea.[263] Because religious leaders can influence voters, and because voters can influence policy in more democratic states, religious leaders have some level of power within the model, even if it is modest.

Stakeholder Classification

For the purpose of this model, stakeholders are imbued with certain attributes: Power (P_i), legitimacy (L_i), urgency (U_i), and prominence. Power is an actor's ability to get another actor to do something that they would not otherwise do.[264] In this sense power is relative. States certainly have more power than non-states in this model. Ultimately, without extreme coercion, states cannot be compelled to give up their weapons programs. Legitimacy is the view that a

[263] Sarah Pulliam Bailey, "'God has given Trump authority to take out Kim Jong Un,' evangelical adviser says," *The Washington Post*, August 9, 2017. https://www.washingtonpost.com/news/acts-of-faith/wp/2017/08/08/god-has-given-trump-authority-to-take-out-kim-jong-un-evangelical-adviser-says/.
[264] Ronald K. Mitchell, Bradley R. Agle, and Donna J. Wood, "Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts," *The Academy of Management Review* 22, no. 4 (1997): 869.

given stakeholder's actions "are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, definitions."[265] Once again, states hold dominant legitimacy. An exception to this rule might be the DPRK, which the international community feels has violated norms against proliferation; this is not reflected in Problem 1, but Outlier States, such as the DPRK, are modeled into Problem 2 and the "Mess." Urgency is the "degree to which stakeholder claims call for immediate attention."[266] In this model these attributes fall on a binary range. Either stakeholders possess these attributes, or they do not. Finally, prominence is the average of the respective stakeholder's attributes

$$Prominence_i = [P_i + L_i + U_i]/3$$

and "represents a relative level of importance of each stakeholder to a given problem."[267]

Stakeholders can be placed into one of eight different classes depending on prominence. They can be further placed into one of four stakeholder classifications. These are identified in Table 5.3.

Latent stakeholders have the least prominence and are the least important in the system. Expectant stakeholders are secondary actors in the system because they exhibit two attributes. Finally, definitive are primary actors because they exhibit all three traits. For this research, Table 5.4 shows this model's stakeholders and their attributes, class, and classification.[268]

---

[265] Mitchell, et al, 869.
[266] Mitchell, et al, 869.
[267] Hester and Adams, 137.
[268] For a discussion on the rationales for stakeholder classification and identification, see Table 2: Mitchell, et al, 860-862.

Table 5.3: Stakeholder Classes and Classifications[269]

Class	Description	Classification
Dormant	Powerful, not legitimate, not urgent	Latent
Discretionary	Legitimate, not powerful, not urgent	Latent
Demanding	Urgent, not powerful, not legitimate	Latent
Dominant	Powerful, legitimate, not urgent	Expectant
Dangerous	Powerful, urgent, not legitimate	Expectant
Dependent	Legitimate, urgent, not powerful	Expectant
Definitive	Powerful, legitimate, urgent	Definitive
Nonstakeholder	Not powerful, not legitimate, not urgent	Undefined

Table 5.4: Problem 1 Stakeholder Classification

Stakeholders	Power	Legitimacy	Urgency	Prominence	Class	Classification
NWs states	1	1	0	0.67	Expectant	Dominant
Production Firms	0	1	1	0.67	Expectant	Demanding
Stockholders	0	1	0	0.33	Latent	Discretionary
International verification and compliance agencies	1	1	1	1.00	Definitive	Definitive
NGOs and activists	0	1	1	0.67	Expectant	Demanding
Media	0	1	0	0.33	Latent	Discretionary
NPT states	0	1	1	0.67	Expectant	Demanding
Religious leaders	0	1	0	0.33	Latent	Discretionary

Stakeholder Attitude Evaluation

Before determining strategies for each stakeholder, stakeholder attitudes must be evaluated. Stakeholder potential for threat and cooperation determines strategies. Adapting from

[269] Adapted from Hester and Adams, 138.

Savage, et al, stakeholders with mixed attitudes have both high potential for threat and cooperation. High potential for cooperation and low potential for threat indicates supportive attitudes. Low potential for cooperation and high potential for threat suggests non-supportive attitudes. Both low potential for threat and cooperation indicates marginal attitudes. Savage, et al, then add the strategies are defined as thus: collaborate with mixed stakeholders, involve supportive stakeholders, defend against non-supportive stakeholders, and monitor marginal stakeholders.[270] Table 5.5 shows this model's stakeholder attitudes and strategies. Support is determined through a simple Cooperate minus Threat calculation.

Table 5.5: Problem 1 Stakeholder Attitudes and Strategies

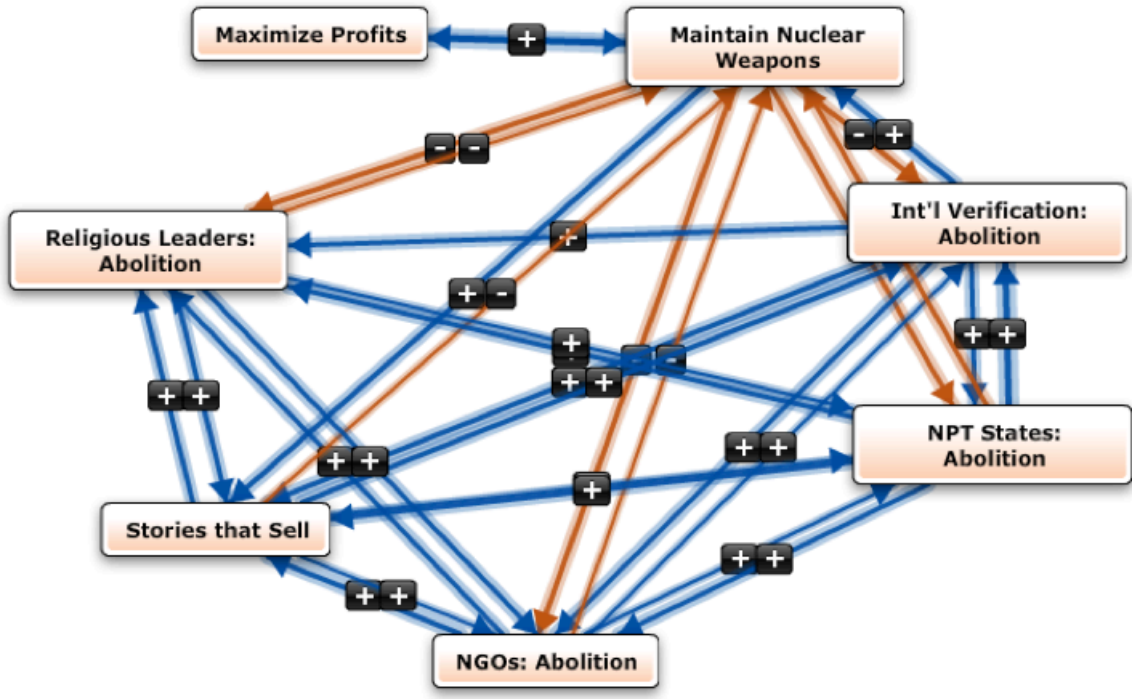
Stakeholders	**Threat**	**Cooperate**	**Support**	**Attitude**	**Strategy**
NWs states	1	1	0	Mixed	Collaborate
Production Firms	1	0	-1	Non-supportive	Defend
International verification and compliance agencies	0	1	1	Supportive	Involve
NGOs and activists	0	1	1	Supportive	Involve
Media	0	0	0	Marginal	Monitor
NPT states	0	1	1	Supportive	Involve
Religious leaders	1	1	0	Mixed	Collaborate

FCM for Stakeholder Objectives

Figure 5.1 shows this model's initial FCM with stakeholders and objectives.

[270] Grant T. Savage, Timothy W. Nix, Carlton J. Whitehead, "Strategies for Assessing and Managing Organizational Stakeholders," *The Executive* 5, no. 2 (1991): 65.

Figure 5.1: Problem 1 FCM Who



Stakeholder Management Plan

At this point in the modeling, the objective is to develop a stakeholder management plan. This plan allows practitioners and stakeholders an opportunity to determine how resources and effort should be distributed in order to maintain stakeholder support. Table 5.6 shows the stakeholder management plan from previous steps in the modeling, in addition to stakeholder engagement priorities. Table 5.6 combines stakeholder wants, strategies, and metrics from Table 5.5. Stakeholder engagement priority is set by arranging metrics. The metrics are summarized with qualifying justification in Table 5.7. Nodes and weighted links from the FCM model determine Activity and Popularity for each stakeholder. Activity is set by OutDegree in descending order. Popularity is set by InDegree in descending order. Priority is set by Activity in ascending order and then Popularity in descending order (to break ties).

Table 5.6: Problem 1 Stakeholder Management Plan

Stakeholder	Strategy	InDeg	OutDeg	Activity	Popularity	Engagement Priority
Maintain Nuclear Weapons	Collaborate	2	3.5	4.582576	3.464102	1
NPT States: Abolition	Involve	2	3.25	4.031129	3.162278	2
Int'l Verification: Abolition	Involve	2.25	3	3.872983	3	3
NGOs: Abolition	Involve	2.75	2	3.162278	3.708099	4
Stories that Sell	Monitor	2.5	1.75	2.95804	3.535534	5
Religious Leaders: Abolition	Collaborate	2.75	1.5	2.44949	3.708099	6
Maximize Profits	Defend	1	0.25	0.5	1	7

Table 5.7: Problem 1 Who Qualitative Link Justification

Sender Component	Receiver Component	Link	Reasoning
NW States: Nuclear Weapons	Production Firms: Maximize Profits	1	NWS provide production contracts to various firms.
NW States: Nuclear Weapons	Int'l Verification: Abolition	-0.5	By desiring nuclear weapons NWS moderately decrease the IAEA's mission in 2 ways: 1) it blocks the IAEA's ability to enforce NPT Article VI, 2) they use voluntary offer agreements, which restrict what the IAEA can do.
NW States: Nuclear Weapons	NGOs: Abolition	-0.5	NWS moderately decrease NGOs' ability to operate, but NGOs will continue their missions, despite hurdles.
NW States: Nuclear Weapons	Stories that Sell	0.5	States moderately increase the media's ability to sell stories. It does not graduate to strong because the media might find more profitable stories, depending on circumstances.

NW States: Nuclear Weapons	NPT States: Abolition	-0.5	NWS moderately decrease NPT states' mission, but the NPT also focuses on non-NWS.
NW States: Nuclear Weapons	Religious Leaders: Abolition	-0.5	NWS moderately decrease Religious Leaders, but these leaders continue their work.
Production Firms: Maximize Profits	NW States: Nuclear Weapons	0.25	Firms can lobby the government to continue production orders; however, this link is weak because the state can do as it pleases, and it does not need Production Firms' blessings.
Int'l Verification: Abolition	NW States: Nuclear Weapons	-0.5	This link is moderate because, while NWS can simply ignore the IAEA if they choose, they do not choose to ignore them. This relationship changes as NWS goal changes.
Int'l Verification: Abolition	NGOs: Abolition	0.75	IAEA communications and data strongly help the NGO mission.
Int'l Verification: Abolition	Stories that Sell	0.5	IAEA communications help the media sell stories moderately. The media can also choose to run other stories.
Int'l Verification: Abolition	NPT States: Abolition	0.75	The IAEA directly assists the NPT states.
Int'l Verification: Abolition	Religious Leaders: Abolition	0.5	This relationship is moderate. While the IAEA has the power to do what Religious Leaders hope, Religious Leaders ultimately cannot do those things.
NGOs: Abolition	NW States: Nuclear Weapons	-0.25	NGOs can lobby governments, but this relationship is weak; governments can simply ignore them.
NGOs: Abolition	Int'l Verification: Abolition	0.25	NGOs can supply the IAEA with information, but this information is a small part of the information the IAEA collects.
NGOs: Abolition	Stories that Sell	0.5	NGOs moderately increase the Media's ability to sell stories, but the media can ignore them.
NGOs: Abolition	NPT States: Abolition	0.25	NGOs can lobby governments, but this relationship is weak; governments can simply ignore them.
NGOs: Abolition	Religious Leaders: Abolition	0.75	NGOs and Religious Leaders often work together for a common cause.

Stories that Sell	NWs States: Nuclear Weapons	-0.25	The Media can sell more stories by reporting on negative things about governments, but this relationship is weak because there are many stories in the day.
Stories that Sell	Int'l Verification: Abolition	0.5	The Media can report on IAEA inspection results or comments from the Board of Governors.
Stories that Sell	NGOs: Abolition	0.25	The media can help NGOs, but NGOs also receive help from much larger organizations.
Stories that Sell	NPT States: Abolition	0.25	See above.
Stories that Sell	Religious Leaders: Abolition	0.5	Religious leaders often use the media.
NPT States: Abolition	NWs States: Nuclear Weapons	0.5	The non-nuclear norm moderately affects NWS behaviors.
NPT States: Abolition	Int'l Verification: Abolition	1	NPT States make up a super majority of the IAEA.
NPT States: Abolition	NGOs: Abolition	0.75	NPT States often work with NGOs.
NPT States: Abolition	Religious Leaders: Abolition	0.5	NPT States often work with Religious Leaders, but religious leaders do not have huge amounts of resources.
Religious Leaders: Abolition	NWs States: Nuclear Weapons	-0.25	Religious Leaders can sway the minds of some voters, but not in less-than-democratic states, and not to a massive degree, especially when national security is on the line.
Religious Leaders: Abolition	NGOs: Abolition	0.5	Religious Leaders can give a moral authority to NGOs.
Religious Leaders: Abolition	Stories that Sell	0.5	Religious leaders can make authoritative statements to the press.
Religious Leaders: Abolition	NPT States: Abolition	0.25	This relationship is weak because states can operate independently from the church.

Summary

This model is largely consistent with realist assumptions of states as primary drivers of international politics hold. On the other hand, international verification and compliance agencies,

NPT states, and NGOs must not be discounted. Involvement from abolitionist stakeholders and collaboration with nuclear weapons states are crucial actions that can synthesize the disarmament antitheses. Decision makers should monitor the media to look for signs that they have taken a supportive or non-supportive position. Finally, religious leaders should be consulted for collaboration because they can influence state leaders and, importantly for democracies, constituents. Religious leaders can communicate with their flock that disarmament is the moral option. However, they do have the potential to defect from their abolitionist position. This stakeholder analysis should be continuously monitored for changes.

Before moving on another stakeholder must be identified. The view that all nuclear weapons states are functionally similar is certainly contentious, and this research acknowledges that—although even the DPRK has the capacity for cooperation with the US—states are not wedded to cooperation. Even cooperative states have the potential for defection. Therefore, in Problem 2, Outlier States (the DPRK, India, Israel, and Pakistan) are identified as a distinct actor. This stakeholder mimics nuclear weapons states but behaves differently in key areas that are identified in Problem 2. For the purpose of avoiding redundancies that alter model behavior, this stakeholder does not interact with Problem 1's other components until Problems 1 and 2 are combined to form the final "mess."

5.3 Problem 1: What?

Understanding the "What" of the mess' constituent problems is to break the problem down into its basic elements.[271] In the previous section this research identified stakeholders and their goals and how the pursuit of those goals affects the goals of other stakeholders in the

[271] Hester and Adams, 157.

system. It did not reveal, however, the anatomy of the problems. Therefore, this section seeks to capture the problems' objective narratives, apply a fundamental objective hierarchy and a means-ends network, and update the FCM to address the problems' constituent parts.

Problem 1 Objective Narrative

Problem articulation relies on the foundation that nuclear-armed states' are the primary stakeholders, and their primary collective goal is to simply possess nuclear weapons. Their problem is that there is a continuing debate in the international community between nuclear-haves and actors that want to approach global zero. At the Conference on Disarmament, an international forum tasked with negotiating to global zero, in 2018 U.N. Secretary-General Antonio Guterres argues, "Countries persist in clinging to the fallacious idea that nuclear arms make the world safer … At the global level, we must work towards forging a new momentum on eliminating nuclear weapons."[272] The US, France, and China expressed critical warnings that the international system's future is too uncertain to pursue disarmament negotiations at the present time. On the other hand, nuclear-armed states are actively participating at the forum. The Conference on Disarmament includes ambassadors from every nuclear-armed state, including the DPRK. In other words, nuclear-armed states have not chosen to simply ignore the problem; they are actively contributing to the debate. Furthermore, there is some evidence as of March 2018 that even North Korea is willing to negotiate for abolition. Kim Jong Un met with South Korean envoys to discuss dismantling the North's nuclear weapons program and that the North is willing

[272] Antono Guterres quoted in Tom Miles, "U.N. chief calls for new push to rid the world of nuclear weapons," *Reuters*, February 26, 2018, https://www.reuters.com/article/us-un-arms/u-n-chief-calls-for-new-push-to-rid-the-world-of-nuclear-weapons-idUSKCN1GA1TK.

to disarm if its security needs are met.[273] In June he met with US President Trump to discuss this further. In other words, at face value the DPRK does not see this as a problem of possession, but rather security. If the decisions were out of states' controls, these states, particularly the DPRK and Israel, would be left with uncertain security in an environment they perceive as hostile. In other words, nuclear weapons serve a purpose: Defense. And defense serves a purpose: Security. It is from this position that the objective narrative begins.

Nuclear weapons states collectively aim to balance their security needs with the demands of a highly interconnected international community. If it focuses solely on its security needs it violates norms against proliferation, which affects its access to international goods, trade, or decision-making forums. For example, there is a weak but apparent link between being in good standing with the NPT and IAEA membership. Article VI of the NPT requires nuclear weapons states to take good faith steps towards disarmament. The DPRK left the IAEA in 1994 after its withdrawal from the NPT raised concerns with the IAEA's board of governors. But if the nuclear weapons states focus primarily on the demands of the international community, it undermines its primary goal of possessing nuclear weapons. It can be established, therefore, that nuclear weapons states' fundamental objective is to balance security in the international system with its reputation.[274] Various mechanisms can achieve this goal, which are addressed in the fundamental objectives hierarchy and means-ends network.

Examining the other stakeholders' preferences reveals another justification for focusing on nuclear weapons states as the prioritized stakeholder. From the perspective of international

---

[273] Choe Sang-Hun and Mark Landler, "North Korea Signals Willingness to 'Denuclearize,' South Says," *The Washington Post*, March 6, 2018, https://www.nytimes.com/2018/03/06/world/asia/north-korea-south-nuclear-weapons.html.

[274] For the purpose of this project, "reputation" refers to normative constraints imposed on states at a psychological level.

verification and compliance agencies, NPT states, and NGOs, these fundamental goals are reasonable. NPT states, for example, desire regional security. If nuclear weapons states lost deterrence, many states with security guarantees from nuclear weapons states might fear either defection from those guarantees or spillover from regional conflicts. That is, they seek to avoid making a Type IV error, or making their situations worse. Additionally, due to the high interconnectedness of the planet, non-nuclear weapons states benefit from trade with nuclear weapons states. They support nuclear weapons states' secondary aim of having access to international markets and other goods.

Problem 1 Fundamental Objectives Hierarchy

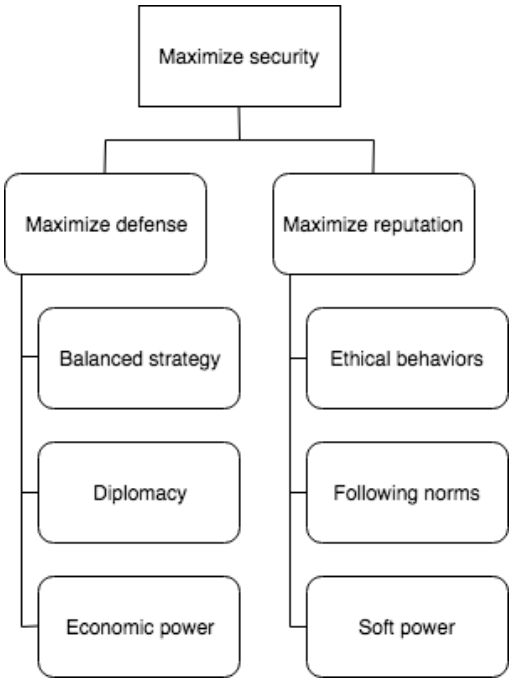
This research identifies two fundamental objectives in the dialectic between nuclear weapons and disarmament: *Maximize defense* and *maximize reputation* (which increases access to various benefits). Maximizing defensive abilities can be broken down to include a balanced strategy (military capability and avoiding making unnecessary threatening behaviors[275]), diplomacy, and economic power. Maximizing reputation is broken down into ethical behaviors, following norms, and soft power.[276] Collectively, these goals are referred to as *maximize security*. These are illustrated in Figure 5.2. The goal of nuclear weapons states can be updated

[275] The "security dilemma" is an inherent reality in the realist structure, where "Striving to attain security from [an] attack, [insecure states] are driven to acquire more and more power in order to escape the impact of the power of others. This, in turn, renders the others more insecure and compels them to prepare for the worst." John H. Herz, "Idealist Internationalism and the Security Dilemma," *World Politics* 2, no. 2 (1950): 157.

[276] Soft power is the ability for actors to get others to act the way it wants through attraction. Joseph S. Nye, "Soft power," *Foreign Policy* no. 80 (1990): 166. See also Barbara G. Haskel, "Access to Society: A Neglected Dimension of Power," *International Organization* 34, no. 1 (1980), 89-120.

from simply possessing nuclear weapons to maximizing security, which, as mentioned, is a combination of high levels of defense and high levels of reputation.

Figure 5.2: Problem 1 Fundamental Objectives Hierarchy



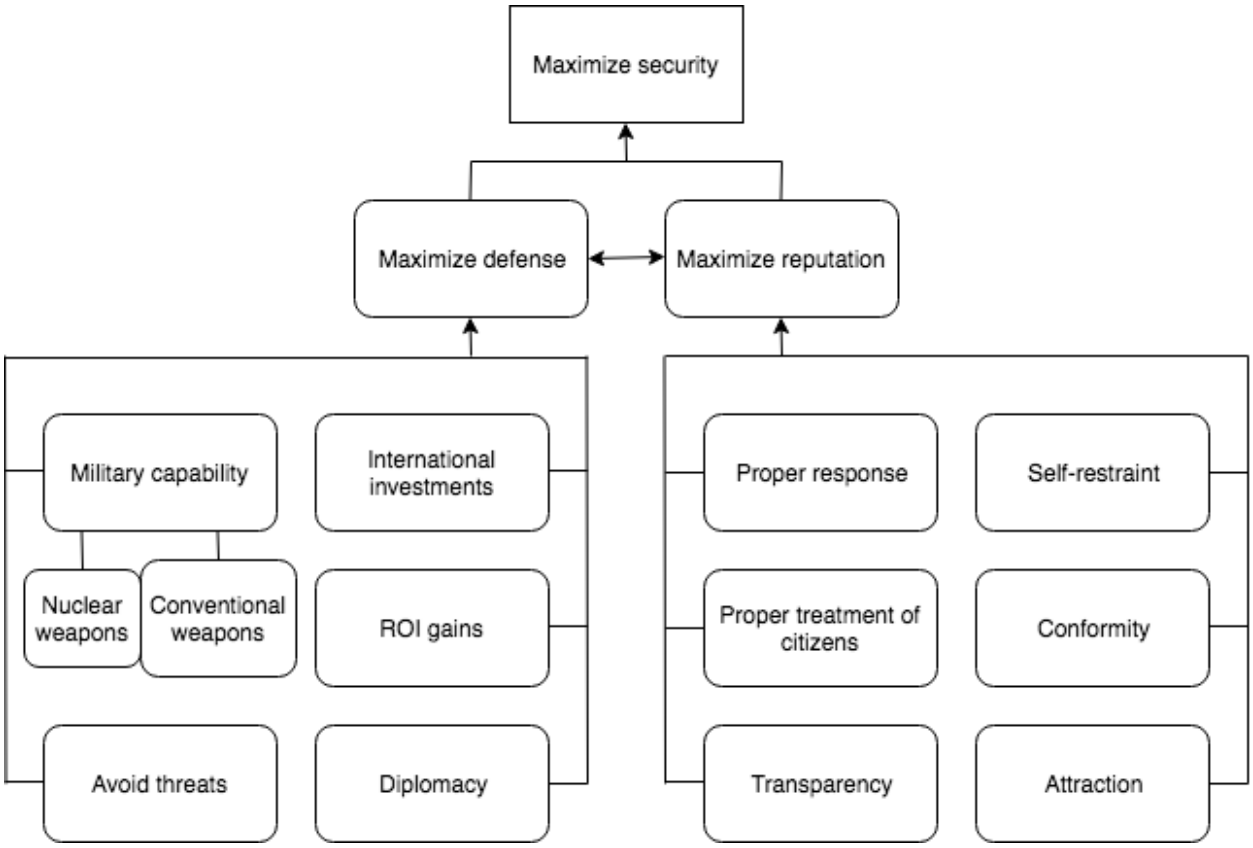
Problem 1 Means-Ends Network

The means-ends network, while similar to the fundamental objectives hierarchy, captures more cause and effect. That is, the point is to ask *how* do or can we achieve our fundamental objectives,[277] or, in case, how is security maximized? Maximizing security includes both defensive capabilities and reputation. Furthermore, maximizing defensive capability is a means by which to maximize reputation (e.g., avoiding war with neighbors means following certain norms), and maximizing reputation is a means by which to maximize defense.

[277] Robert T. Clemen and Terence Reilly, *Making Hard Decisions with Decision Tools*, 3rd Edition (Boston: Cengage Learning, 2013), 52.

Maximizing defense means having adequate military capabilities (this presently includes both nuclear and conventional weapons, for the nuclear weapon state), avoiding unnecessarily threatening postures, having diplomatic relations with others, and increasing economic power through international investments and return on investment gains (i.e., economic partnerships decrease the effects of military threat). Maximizing reputation means properly responding to violations of international norms, treating citizens properly, practicing self-restraint, being transparent, conforming to internationally acceptable forms of behavior, and obtaining desired outcomes through simply attracting others to the state's brand. This is illustrated in Figure 5.3.

Figure 5.3: Problem 1 Means-Ends Network



Problem 1 What FCM

Applying the means-ends network and nuclear weapons states' updated problem statement to Problem 1's FCM shows emergence of new links between *who* and *what*. Of particular note, the causal link between nuclear weapons states' goal and international verification agencies' goal is updated from negative to positive. This is because nuclear weapons states ultimate goal is security. The IAEA works in ways that increase states' security. Additionally, other links are broken. Religious leaders goal of disarmament and the media's goal of selling stories no longer affects nuclear weapons states' goal of maximizing security. The rest of the updates are noted in Table 5.8, and the updated FCM is shown in Figure 5.4.

Figure 5.4: Problem 1 FCM What

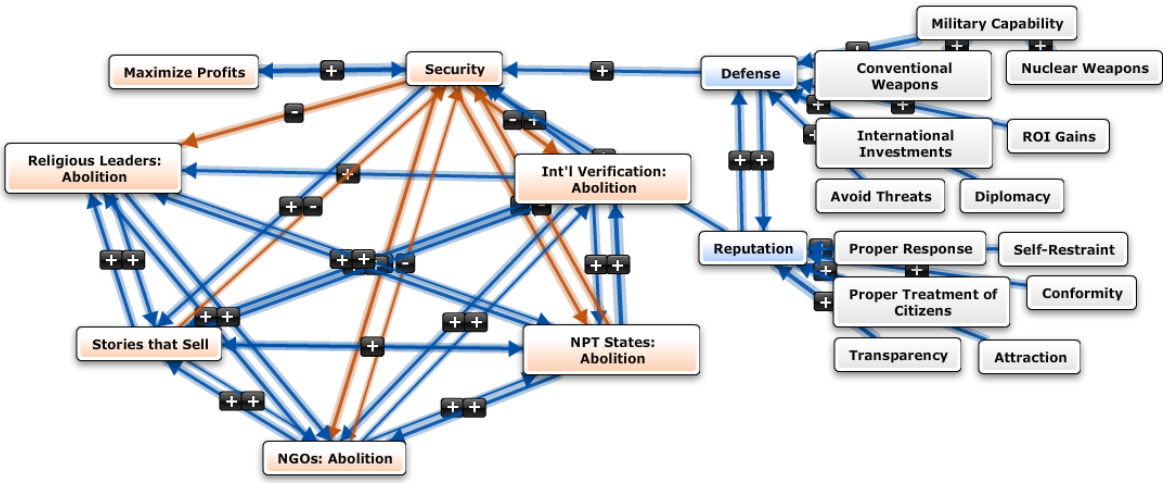


Table 5.8: Problem 1 What Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Reputation	Security	0.75	Reputation strongly increases security because the risk of war declines as states become more reputable to their neighbors.

Reputation	Defense	0.5	Forming half of this positive feedback loop, reputation moderately increases defense by decreasing the risk of conflict.
Defense	Security	0.75	Strong defenses strongly increase security by increasing the opponent's attack cost.
Defense	Reputation	0.5	Forming half of this positive feedback loop, defense moderately increases reputation because strong defense decreases risk of conflict, and lower conflict increases the state's reputation as a member in good standing of the international community.
Military Capability	Defense	1	Military capability is a very strong component of defense.
Diplomacy	Defense	0.75	Diplomatic relations strongly increase defense by making conflict less likely.
ROI Gains	Defense	0.5	Returns on investment increase defense moderately by adding to available military funds.
Nuclear Weapons	Military Capability	1	This relationship is self-explanatory.
Conventional Weapons	Military Capability	1	This relationship is self-explanatory.
International Investments	Defense	0.5	International investments increase defense by making conflict less likely[278]
Avoid Threats	Defense	0.5	Avoiding actions that can be perceived as threatening increases defense by making conflict less likely.
Proper Response	Reputation	0.75	Properly responding to norm violations strongly increases reputation by signaling to the international community that the responder abides by international social norms.
Self-Restraint	Reputation	0.5	By restraining oneself from behavior deemed deviant, reputation as a member in good standing with the international community increases.
Proper Treatment of Citizens	Reputation	0.25	This relationship is weak because international reputation is more concerned with international behavior; however, human rights violations can have a negative impact.
Conformity	Reputation	0.5	Conforming to international norms moderately increases reputation.

[278] Phillip G. Cerny, *Rethinking World Politics: A Theory of Transnational Neopluralism*, Kindle Edition (New York: Oxford University Press, 2010), Kindle Locations 3343-3346.

Transparency	Reputation	1	Transparency very strongly increases reputation by diminishing uncertainty about intentions.
Attraction	Reputation	0.75	Being attractive strongly increases reputation.

5.4 Problem 1: Why?

The first section identified and analyzed nine stakeholders and developed a stakeholder management plan. The second section decomposed the mess' constituent problems into component parts. This section tackles substantive information: motivation analysis, motivation models, and motivation feedback. That is, this research is now looking at the motivating forces—the premises and purposes—behind events and actions. In the Structure, Think, Act, and Observe model from Chapter 3, this would fall under Structure, Restructure. The revised model follows from this restructuring.

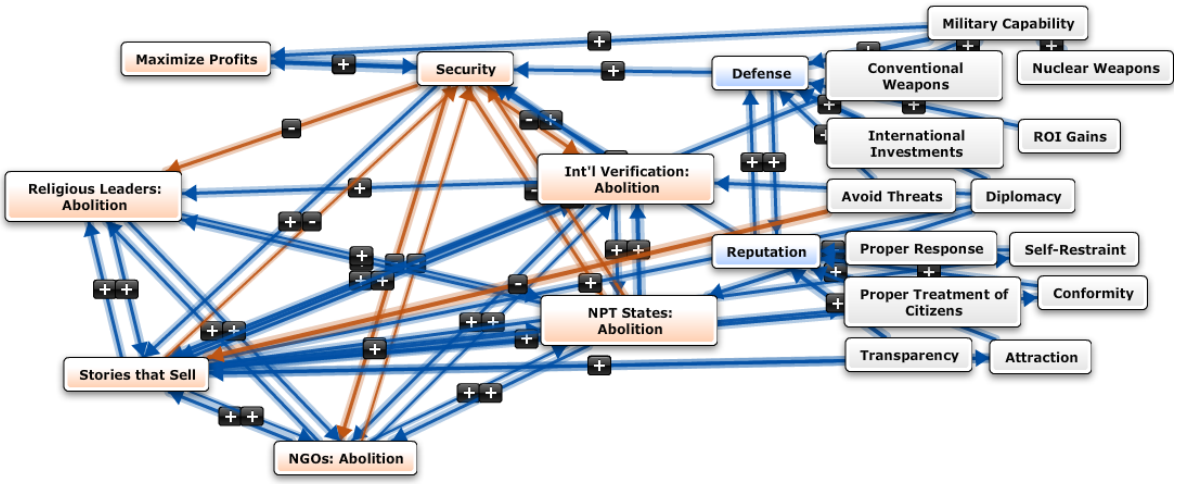
As identified in the first section, the primary actors in Problem 1 are nuclear weapons states, and nuclear weapons states' fundamental goal in Problem 1 is security (remembering that nuclear weapons serve a function, defense, and defense serves a function, security). Another way of stating this is nuclear weapons' primary goal in a hostile world is Maslow's proposed second hierarchical need: Safety.[279] Primarily attention is paid to relationships between other stakeholder objectives, looking for feedback loops. Then necessary modifications to the FCM are made. These updates are explained in Table 5.9 and shown in Figure 5.5.

[279] A. H. Maslow, and Herbert S. Langfeld, "A Theory of Human Motivation," *Psychological Review* 50, no. 4 (1943): 376.

Table 5.9: Problem 1 Why Qualitative Link Justification

Sender Component	Receiver Component	Link	Reasoning
Military Capability	Maximize Profits	0.75	Production firms' profits increase strongly as military capability increases because the production firms are awarded military contracts.
Military Capability	Stories that Sell	0.75	The media enjoys reporting on increased military capability.
Military Capability	Defense	1	Military capability is a very strong component of defense.
Diplomacy	Int'l Verification: Abolition	0.5	As an international body, the IAEA functions diplomatically. In acting diplomatically, NWS uphold the IAEA's mission.
Diplomacy	Stories that Sell	0.5	Diplomatic behavior is often reported in the news.
Diplomacy	NPT States: Abolition	0.5	NPT States utilize diplomacy to further their goals.
Avoid Threats	Stories that Sell	-1	With no threatening behavior to report on, the media is less likely to sell stories.
Attraction	Stories that Sell	0.5	Attractive stories increase the media's ability to sell stories (for example, cinema and new music coming from the state)

Figure 5.5: Problem 1 FCM Why



5.5 Problem 1: Where?

When speaking in terms of "where," this research is tackling two things: the context of the problem and the boundaries. Context is "the circumstances, factors, conditions, values, and patterns that surround messes and problems" and the boundaries are "the representations we use that provide lines of demarcation between messes and problems and the surrounding environment."[280] "Where" does not refer to geographical or physical locations. This section allows the research to be refined in a way that decreases complexity, providing an improved understanding of the problem.

Focusing on the prioritized stakeholders, nuclear weapons states, this research adapts from Ulrich[281] to generate a boundary critique. This force-field diagram is an assessment of *what is* and *what ought to be* in the model.[282] First, identify the sources of motivation. Whose interests are served versus whose should be served? What are and should be the consequences? How can *what is* and *should be* be considered an improvement based on consequences? Second, identify the sources of power. Who is and should be the decision maker? What resources do and should that decision maker control? What decisions are and should be outside the decision maker's control? Third, identify the sources of knowledge. Who are and should be considered the experts? What is and should be considered a source of knowledge? Who does and should guarantee improvement? Finally, identify the sources of legitimacy. Who are and should be the legitimate stakeholders? Where does and should legitimacy lie? How is and should improvement be viewed?

---

[280] Hester and Adams, 207.
[281] Werner Ulrich, "Reflective Practice in the Civil Society: The Contribution of Critically Systemic Thinking," *Reflective Practice* 1, no. 2 (2000): 256.
[282] Ulrich, 259.

Problem 1 Boundary Articulation

The sources of motivation are examined. First, the clients are all stakeholders with formal recognition. This model should serve the interests of at a minimum both nuclear weapons states and NPT states. Second, the purpose is security. The measure of improvement is whether or not various stakeholder goals reduce uncertainty. For example, joining the IAEA reduces uncertainty, which is shown in the following game:

Table 5.10: IAEA and reduction of uncertainty

	2 JOIN	2 DEFECT
1 JOIN	1, 1	0, 0
1 DEFECT	0, 0	0, 0

In the game profit comes from joining because both players must join and make their systems verifiable. Reducing uncertainty by examining another state's materials means making one's materials verifiable. 1 represents profit, while 0 represents the status quo.

Next, the sources of power are assessed. First, nuclear weapons states are the primary decision makers within this problem. No other stakeholder—not even non-nuclear weapons states—can compel disarmament. However, because nuclear weapons can destabilize the system or, if used, intensely burden all states, the decision-making should be a collective effort. Second, decision makers should control resources identified in the means-ends network to maximize reputation. Third, as previously specified, the system cannot be made worse. The outcome cannot be a cause of major instability. Therefore, while states can control overt instability-inducing conditions (e.g., compellence through war), decision makers should not be able to control these conditions.

The next step is to identify sources of power. First, because the IAEA answers directly to the General Assembly and, if need be, the Security Council of the United Nations, and because the United Nations is explicitly a sub-stakeholder part of the international verification and compliance stakeholder, these agencies, along with states (nuclear and non-nuclear), should be considered the primary experts. Second, there are several documents that should provide guidance for knowledge experts. Several of these are identified in Table 5.11. These include treaties, declarations, and statements on morality. Third, the guarantor of success should be an international body, such as the United Nations, where improvement is determined through consensus.

Table 5.11: Problem 1 Sources of Knowledge

Document	Type	Description
Treaty on the Non-Proliferation of Nuclear Weapons (NPT), Article VI[283]	Treaty	Article VI states "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."
Legality of the Threat or Use of Nuclear Weapons[284]	International legal opinion	International Court of Justice opinion that concludes there is not legal reason to prohibit states from possessing nuclear weapons; however, it required states abide by NPT Article VI. All members, including the permanent members of the Security Council, voted to pursue the requirements set forth in NPT Article VI.
United Nations Charter, Chapter 7, Article 51[285]	Treaty	Article 51 upholds UN member states' right to self- and collective defense and requires states invoking this right to submit to the jurisdiction of the UN Security Council.
Treaties under IAEA	Various	These are agreements, conventions, and protocols on

[283] Israel is a non-signatory, and North Korea has withdrawn.
[284] "International Court of Justice: Advisory Opinion on the Legality of the Threat or Use of Nuclear Weapons," *International Legal Materials* 35, no. 4 (1996): 809-938.
[285] United Nations, "United Nations Charter, CHAPTER VII: ACTION WITH RESPECT TO THREATS TO THE PEACE, BREACHES OF THE PEACE, AND ACTS OF AGGRESSION," 1945, http://www.un.org/en/sections/un-charter/chapter-vii/.

Auspices[286]		various organizational, nuclear safety and security, liability, technical cooperation, and scientific and technical areas under IAEA jurisdiction.
The Challenge of Peace: God's Promise and Our Response[287]	Catholic declaration	This document tackles the moral implications of nuclear deterrence and makes the case for disarmament through a Christian lens.
Resolution On Multilateral Arms Control[288]	Southern Baptist Resolution	This document supports arms reductions and the reallocation of resources from nuclear research to human needs.
The Talmud	Jewish holy text	Shavuot 35b forbids nations from conducting war that kills more than one-out-of-six people.[289]
Scientific books and journals	Various	These provide decision makers with the physical, existential, meteorological, psychological, social, and economic effects of nuclear war.

The final step is to examine the sources of legitimacy. First, states are the primary legitimate stakeholders. However, intergovernmental agencies, being made up of sovereign states, should share some of the legitimacy. Second, states should be the emancipatory stakeholders. Intergovernmental agencies shall not replace sovereignty. Lastly, improvement shall be determined as reconciliation between states' security and international security.

Problem 1 Context Articulation

Context is the noticeable and important elements of the problem: the circumstances, factors, conditions, values, and patterns that create new nodes of influence in the model.[290] The circumstances of the international system structure behaviors. For this problem, these include international agreements, such as Article VI of the NPT. Article VI requires nuclear weapons

[286] "Treaties under IAEA Auspices," International Atomic Energy Agency, https://www.iaea.org/resources/treaties/treaties-under-IAEA-auspices.
[287] Daniel F. Hoye, "The Challenge of Peace: God's Promise and Our Response," *National Conference of Catholic Bishops* (May 3, 1983).
[288] "Resolution On Multilateral Arms Control," *Southern Baptist Convention* (1978).
[289] B.T. Shavuot 35b would be in the Babylonian Talmud, Tractate Berachot, Folio 35 back (b) side.
[290] Hester and Adams, 211-212.

states to make progress towards disarmament in good faith. Other requirements are included in Table 5.11 above.

Factors are invariable realities. Because this research avoids the Hobbesian solution to this problem, the circumstances operate in a factor of anarchy. Within an anarchical system uncertainty prevails as a second unavoidable factor. While states and intergovernmental agencies can work to mitigate the effects of anarchy and uncertainty, it is not possible to reduce these factors to negligible levels in the foreseeable future. Nuclear weapons states therefore accept the nuclear risk in hopes of managing uncertainty.

The conditions refer to the current state of the world that influences the outcome of the model. These include the risk of nuclear terrorism and the risk of human error. Conditions can change without notice; therefore, these must be continuously monitored. For example, a major, non-nuclear war between superpowers is a potential factor that could disrupt the present-day's model output. While real, the threat of war, accident, or terrorism is not—at this moment—modeled as actual wars, accidents, or attacks.

Values are strongly held beliefs that shape behavior. This includes nonproliferation, disarmament, and no first use or first strike policies. For example, behavioral norms pressure states to not violate the provisions of the NPT. While states not in good standing with the NPT can ignore Article VI (the DPRK and Israel, for example), these states cannot avoid the social stigma that comes with being in bad standing.

Finally, patterns are generally acceptable, structurally perceived, and recurring behaviors in the international system. The effects of conflict and cooperation are relatively predictable and either mitigate or exasperate the effects of anarchy and uncertainty. Conflict is likely to reduce certainty and increase the perception of the anarchical structure of the system. Cooperation is

likely to reduce uncertainty, particularly if managed by intergovernmental agencies, and mitigate the structural forces of anarchy.

Table 5.12: Problem 1 Context Articulation

Category	Elements
Circumstances	International agreements
Factors	Anarchy, uncertainty
Conditions	Risk of nuclear terrorism, human error
Values	Behavioral norms
Patterns	Conflict, cooperation

There are several competing elements within this problem. International agreements, the risk of nuclear terrorism, behavioral norms, and the potential for cooperation drive this problem towards resolution; however, anarchy, uncertainty, and the potential for conflict serve as roadblocks.

Force Field Diagram

The force field diagram combines new elements from the context and boundary articulations. This seeks to analyze what *is* and what *ought to be*. Ultimately, this is a problem of uncertainty, which prevents abolitionist groups and nuclear weapons states from finding a mutually beneficial resolution to this problem. This is reflected in Table 5.13.

Table 5.13: Problem 1 Force Field Diagram

Driving Force	Strength as-is	Strength ought-to-be	Problem	Restraining force	Strength as-is	Strength ought-to-be
International Agreements	0.5	1	Present State: States operate under anarchy and uncertainty, which decreases security. Idealized State: They should abide by UN Charter Article 51 and work closer with international verification and compliance agencies that have significant power to reduce uncertainty.	Uncertainty	-1	-0.25
Risk of Nuclear Terrorism	0.25	1[291]		Anarchy	-1	-0.25
Behavioral Norms	0.5	1		Conflict	-1	-0.25
Cooperation	0.5	1				

Proposed Ought-to-Be Changes

Nuclear-armed states should embrace cooperation as a means by which to reduce uncertainty and increase security. This inevitably means states should work closer with international verification and compliance agencies, abiding by international norms, and abiding by existing international agreements. The risk of nuclear terrorism is another reality that can greatly reduce states' security; however, the probability for non-state actor proliferation is low.

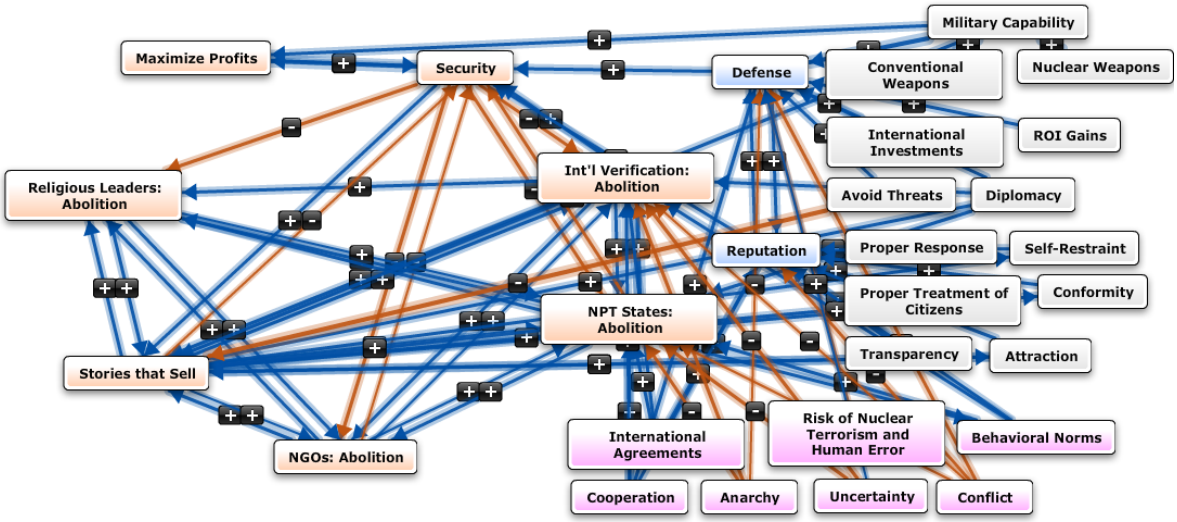
[291] That is, the risk of terrorism should be a driving force; this change in no way implies terrorists should have more power.

Table 5.14: Problem 1 Where Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
International Agreements	Int'l Verification: Abolition	0.75	Existing international agreements strongly increase the IAEA's ability to perform its mission.
International Agreements	NPT States: Abolition	0.75	Existing international agreements strongly increase the NPT States' ability to perform their mission.
International Agreements	Reputation	0.75	Existing international agreements signal to the world that signatory states are in good international standing.
Risk of Nuclear Terrorism and Human Error	Defense	-0.25	These are inherent risks, but their probability is low.
Behavioral Norms	Int'l Verification: Abolition	0.5	Presently, nonproliferation is the norm, but it is not universal.
Behavioral Norms	NPT States: Abolition	0.5	Presently, nonproliferation is the norm, but it is not universal.
Behavioral Norms	Reputation	0.5	Abiding by Behavioral Norms moderately increases Reputation. This relationship does not graduate to strong because other things (like attraction) also increase reputation.
Cooperation	Int'l Verification: Abolition	0.75	Cooperation strongly increases the IAEA's mission because cooperative behavior is the cornerstone of the IAEA Charter.
Cooperation	NPT States: Abolition	0.75	Cooperation between NPT states forms the nonproliferation regime.
Cooperation	Reputation	0.5	Cooperation moderately increases reputation.
Cooperation	Defense	0.5	Cooperation decreases the likelihood of conflict.
Anarchy	Int'l Verification: Abolition	-0.5	Anarchy is a structural force that mitigates the IAEA's ability to function.
Anarchy	NPT States: Abolition	-0.5	Anarchy decreases the likelihood that the nonproliferation regime will survive on a long enough timeline.
Anarchy	Defense	-0.25	Anarchy weakly decreases Defense by creating a system where conflict is possible.
Conflict	Int'l Verification: Abolition	-0.25	Militarized international disputes are rare, but when they occur they have a small potential for incentivizing proliferation.

Conflict	NPT States: Abolition	-0.25	Militarized international disputes are rare, but when they occur they have a small potential for incentivizing proliferation.
Conflict	Reputation	-0.5	Conflicts between states moderately reduce those states' reputations because those states have violated a norm against militarized international disputes.
Conflict	Defense	-0.75	Using defensive capabilities and having those capabilities attacked strongly reduces defensive capability.
Uncertainty	Int'l Verification: Abolition	-0.5	This psychological pressure incentivizes defection but only moderately.
Uncertainty	NPT States: Abolition	-0.75	This psychological pressure strongly undermines the NPTs mission by disincentivizing nonproliferation.
Uncertainty	Defense	0.25	Uncertainty weakly increases defensive capability by incentivizing weapon production.
Religious Leaders: Abolition	Behavioral Norms	0.5	Religious leaders have a moderate ability to define morality within a society.
Stories that Sell	Self-Restraint	0.5	The media can report on deviant behavior, which pressures states to practice restraint.
Stories that Sell	Proper Treatment of Citizens	0.5	The media can report on deviant behavior, which pressures states to treat citizens properly.
Stories that Sell	Conformity	0.5	The media can report on deviant behavior, which pressures states to conform.
Stories that Sell	Attraction	0.75	The media is a driving force behind attraction.

Figure 5.6: Problem 1 FCM Where



5.6 Problem 1: How?

Now that the problem is beginning to take on significant structure, this research can turn to the specific means by which the international system can reach its goals. That is, what are the mechanisms by which the international system can move from its present state—disagreement over the role nuclear weapons play—and the desired state—a world without nuclear weapons that maintains states' security needs? Amarel calls these mechanisms "a set of relevant moves that can be applied from a state to obtain a new state."[292] Hester and Adams note there are three mechanism categories: Human mechanisms, abstract mechanisms, and physical mechanisms, which are further broken down into nine unique mechanisms that do not work alone, but rather in concert with one another.[293] Human mechanisms include human capital and knowledge, skills, and abilities. Abstract mechanisms include methods and information. Physical mechanisms include material, money, time, equipment, and facilities.

[292] Saul Amarel, "On the mechanization of creative processes," *IEEE Spectrum* 3, no. 4 (1966): 112.
[293] Hester and Adams, 232.

Based on the previous section's force field diagram, the preferred state is one where nuclear weapons states make better use of verification agencies and UN Charter Article 51 to mitigate the restraining forces. Transitioning from the present state of the world, where anarchy is more of an ordering mechanism than verification, is to transition from less ordered to more ordered in accordance with Booth's "utopian realism." Hester and Adams propose a Cynefin framework to move from un-order to order.[294] This includes five domains of order and un-order. Disorder exists at the center. Surrounding this domain begins on the ordered side—simple (known-knowns) and complicated (known-unknowns)—and traverses into un-order—complex (unknown-knowns) and chaotic (unknown-unknowns).

Problem 1 Cynefin Analysis

Problem 1 appears relatively ordered, placing it in the complicated domain. That is, there does not appear to be unknown elements of complexity and chaos. However, there are still the known-unknowns, such as uncertainty under anarchy. This stems from a lack of verifiable information, even under the purview of safeguards and verification. Hedging is still a possibility, and outright cheating is certainly not beyond the realm of possibilities. Therefore, stakeholders' objectives should apply the appropriate mechanisms, which includes various human, abstract, and physical nodes. These mechanisms describe the means by which one can transform the problematic situation as presented above into a state that is more desirable.[295]

[294] Hester and Adams, 242.
[295] Hester and Adams, 231.

Problem 1 Mechanism Analysis

Most noticeably, gaining information from nuclear weapons and nuclear energy states requires significant human capital and money. However, on the abstract side, as the world approaches global zero, significant verification improvements must be developed to ensure proper safeguards of nuclear components as well as automatic short lead-in times for re-proliferation. Safeguard improvements include beginning accountancy at the refining process, safeguards for potentially weaponizable isotopes, increased inspection frequency, safeguards to detect small material diversions, increased violation detection systems, better violation reporting, and establishing a good track record of violation identification.[296] Short lead-in times for re-proliferation discourages re-proliferation by giving states the ability to retaliate against new proliferations or re-proliferations. In short, it gives previous nuclear weapons states the option to build nuclear weapons in short order.[297] This helps stabilize the system in two ways: 1) it encourages nuclear weapons states to sign international agreements to disarm by giving them the option to hedge or defect later, and 2) it makes hedging or defecting costly. Therefore the mechanisms include safeguard improvements and re-proliferation capabilities.

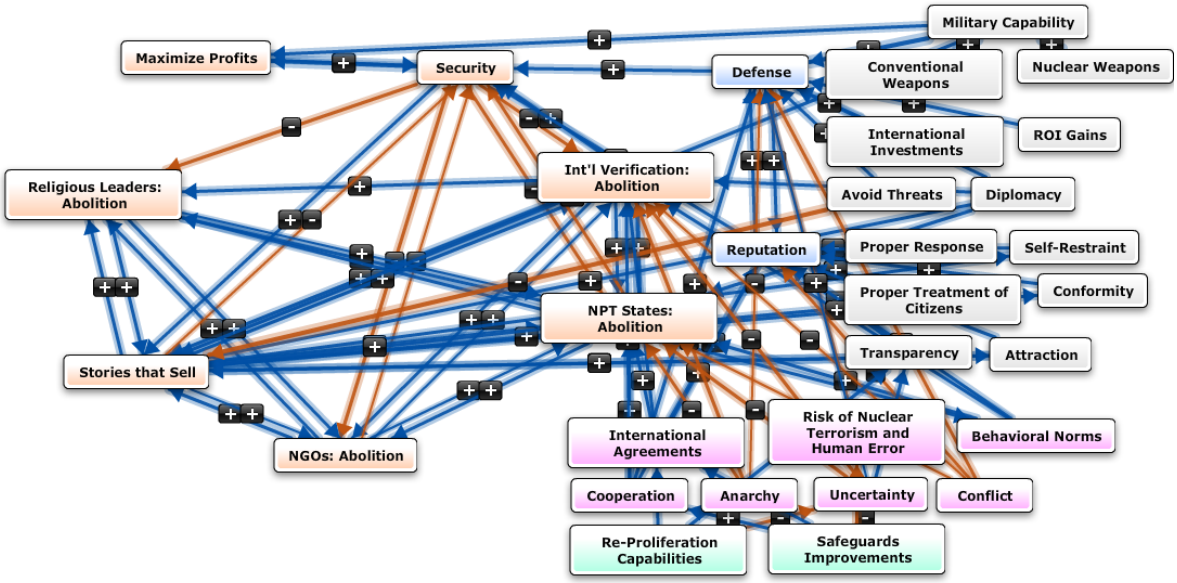
Table 5.15: Problem 1 How Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Re-Proliferation Capabilities	Transparency	0.5	Re-Proliferation Capabilities must be open in order to achieve proliferation deterrence, but this relationship is not perfect.
Re-Proliferation Capabilities	International Agreements	0.5	Re-Proliferation Capabilities moderately increase the chances of successful International Agreements by providing signatory states with assurances.

[296] Perkovich and Acton, 73-74.
[297] Perkovich and Acton, 102.

Re-Proliferation Capabilities	Uncertainty	-0.5	Re-Proliferation Capabilities moderately decrease uncertainty by offering assurances that proliferation will beget proliferation.
Safeguards Improvements	Transparency	0.75	This relationship is strong. A unit increase in improvement greatly increases the international community's ability to monitor nuclear programs worldwide. This is exemplified by the functional differences between the CSA and the AP, which allows complementary accesses with little to no notice.
Safeguards Improvements	International Agreements	0.5	This relationship is moderate because improving safeguards reinforces the normative structure of the international agreements to which they are assigned. This relationship is not perfect, however, because future developments might privilege sovereign constraints.
Safeguards Improvements	Risk of Nuclear Terrorism and Human Error	-0.75	Regular monitoring strongly reduces the risk of inadvertent use or misuse of nuclear materials.
Safeguards Improvements	Cooperation	0.5	Safeguards Improvements moderately increase Cooperation by reinforcing norms.
Safeguards Improvements	Uncertainty	-0.75	Improving safeguards strongly reduces uncertainty by increasing the ability to detect diversion or other illicit activities.

Figure 5.7: Problem 1 FCM How



5.7 Problem 1: When?

The final step in Hester and Adam's FCM technique is to assess when intervention is appropriate. To determine the appropriate time Hester and Adams attempt to determine "if *any* option exists for intervention in our system that provides a larger benefit than its associated cost,"[298] using an inequality where $\max\left(\frac{Benefit}{Cost}\right) \geq 1$. That is, what is the actual cost of an intervention compared to the benefit of intervening? In the system constructed for Problem 1, can the cost of finding a synthesis between nuclear weapons states and the abolition movement be justified given the potential payout? If the system in which this problem exists is too mature (e.g., if the present system of states is expected to be replaced in the foreseeable future) then the inequality is not met; however, if it is assumed the system is not too mature *and* requires near-term intervention then, by definition, the inequality is met.

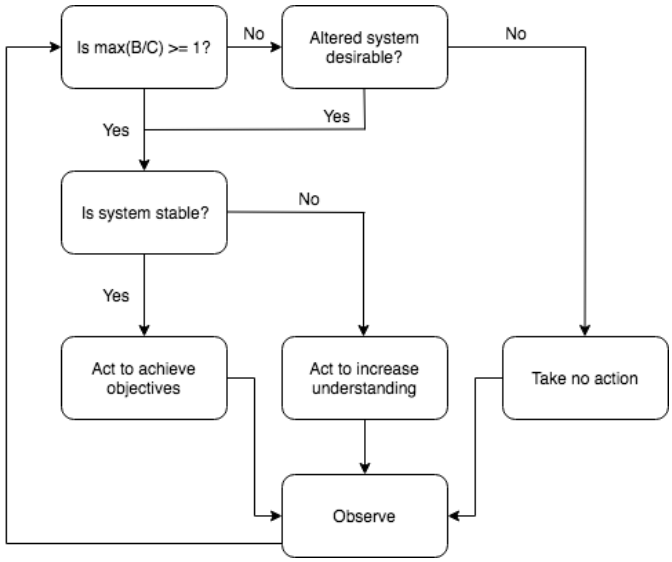
It is unlikely the present-day system of states under anarchy is going to be replaced by some other ordering mechanism in the near term. Further, other stakeholders, such as verification

[298] Hester and Adams, 257.

agencies, are unlikely to disappear in short order. Finally, a world where security is maximized and where the threat of nuclear war, attack, or accident is erased is a world that benefits all stakeholders. Therefore, $\max\left(\frac{Benefit}{Cost}\right) \geq 1$ can reasonably be assumed. In other words, the problem warrants some form of intervention.

The problem appears fairly stable. There are few, if any, unknown-unknowns that might add chaotic elements to the problem. If the inequality is met, and if the system is stable, then the correct course of action, as identified in Figure 5.8, is to act to achieve objectives.

Figure 5.8: Courses of Action (Adapted from Hester and Adams)[299]



Hester and Adams' technique then provides a framework for determining timescale. They require that all concepts operate on the same timescale, and proscribe increasing or decreasing weights depending on changes in time.[300] In this problem there is no definitive time horizon.

[299] Hester and Adams, 268.
[300] Hester and Adams, 270.

System evolution will continue, and no differences in timescale exist between nodes. Because the timescale is immediate and ongoing, no changes to the FCM are necessary.

Problem 1: Intervention Timing

Finally, referring back to Figure 5.8, this project concludes that $\max\left(\frac{Benefit}{Cost}\right) \geq 1$. The system is stable and operating on a standardized timeline. The next step is to determine how the status quo should appear. Therefore, a few scenarios are run.

The first step in intervention is to calculate popularity and activity. This will provide a list of ranked concepts to investigate. Table 5.16 shows popularity, activity, and whether or not changing these variables is feasible. Popularity is a measure of the weights going into a concept set in descending order from highest popularity to lowest. Activity is a measure of the weights coming out of a concept set in descending order from highest activity to lowest. Measuring the activity rank in ascending order and popularity rank in descending order sets the engagement priority.

Table 5.16: Problem 1 Popularity, Activity, and Feasibility

Concept	**Activity**	**Popularity**	**Engagement Priority**	**Change Feasible?**
Stories that Sell	6	6.873864	1	N
Security	4.582576	4.769696	2	Y
Safeguards Improvements	4.031129	0	3	Y
NPT States: Abolition	4.031129	8.485281	4	Y
Int'l Verification: Abolition	3.872983	8.124038	5	Y
Cooperation	3.162278	0.707107	6	N
NGOs:	3.162278	3.708099	7	Y

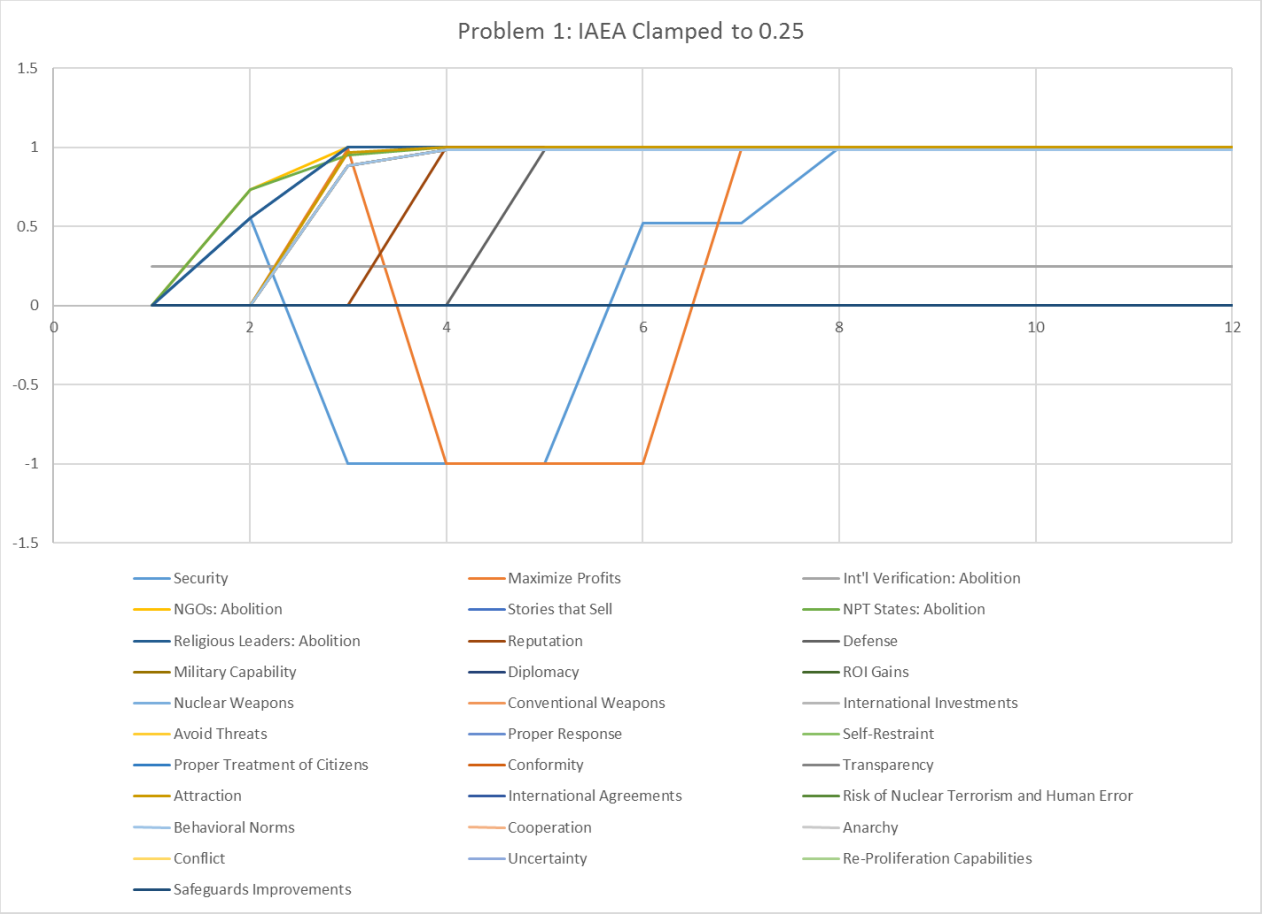
Abolition				
Diplomacy	3	0	8	Y
Military Capability	2.738613	2	9	Y
Conflict	2.645751	0	10	N
Religious Leaders: Abolition	2.645751	3.708099	11	Y
International Agreements	2.598076	1.414214	12	Y
Re-Proliferation Capabilities	2.12132	0	13	Y
Behavioral Norms	2.12132	0.707107	14	N
Uncertainty	2.12132	1.581139	15	N
Anarchy	1.936492	0	16	N
Avoid Threats	1.732051	0	17	Y
Attraction	1.581139	0.866025	18	N
Defense	1.581139	7.952987	19	Y
Reputation	1.581139	8.455767	20	N
Nuclear Weapons	1	0	21	Y
Conventional Weapons	1	0	22	Y
Transparency	1	1.581139	23	Y
Proper Response	0.866025	0	24	Y
ROI Gains	0.707107	0	25	N
International Investments	0.707107	0	26	Y
Self-Restraint	0.707107	0.707107	27	Y
Conformity	0.707107	0.707107	28	N
Proper Treatment of Citizens	0.5	0.707107	29	Y
Risk of Nuclear Terrorism and Human Error	0.5	0.866025	30	N
Maximize Profits	0.5	1.870829	31	N

For the first scenario, international compliance and verification agencies are clamped at 0.25. This simulates a small increase in adherence to IAEA safeguards. All remaining nodes will begin at zero. Zero in this simulation represents no change from the status quo. A change in +1 represents a maximum increase, and a change in -1 represents a maximum decrease.

The following simulation utilizes a sigmoid transfer function, applies a *lambda* of 5,[301] and runs for 50 iterations (to allow sufficient time for hidden chaotic behavior to emerge; however, the results will be truncated at the twelfth timestamp to reflect where equilibrium is achieved). The results are shown in Figure 5.9.

[301] Lambda used here is a constant for function slope. Smaller lambda values ($\lambda \leq 1$) approximate linear functions, large lambda values ($\lambda \geq 10$) approximate discrete functions, and lambda values around 5 represent a good "degree of fuzzification." Elpiniki I. Papageorgiou, *Fuzzy Cognitive Maps for Applied Sciences and Engineering: From Fundamentals to Extensions and Learning Algorithms* (Dordrecht: Springer, 2013), 180-181.

Figure 5.9: Problem 1 Stability Analysis: International Verification



At timestamp 0 the IAEA's goal of International Verification is clamped at a minor increase. By timestamp 1 this results in a moderate increase in Nuclear Weapons States' Security, as well as moderate to significant increases in NGOs, the Media, NPT States, and Religious Leaders' goals. Self-Restrain, Proper Treatment of Citizens, Conformity, Attraction, and Behavioral Norms all experience a permanent maximum increase.

These changes, particularly Abolition goals, result in a maximum decrease of Security by timestamp 2. On the other hand, NGOs, the Media, NPT States, and Religious Leaders experience a maximum increase in their goals, which remain maximized through the end of the

simulation. Self-Restrain, Proper Treatment of Citizens, Conformity, Attraction, and Behavioral Norms all experience a permanent maximum increase.

Timestamp 3 shows continued maximum reductions in Security. Additionally, Production Firms' profits experience a dramatic decline, due to Security reductions. Reputation is permanently maximized. The only significant change in timestamp 4 is the increased demand for Defense.

By timestamp 5 increased Defense has led to increased Security, and by timestamp 6 these have led to a permanent maximization of Profits. Finally, by timestamp 7 equilibrium is reached, were all stakeholders benefit from the new arrangement with the IAEA.

This scenario reached a stable end state, and the situation is complicated. All stakeholders benefit from increased cooperation with the IAEA. Of particular note, nuclear weapons states' security is maximized. On the other hand, anarchy and uncertainty have not been mitigated. Therefore, if the nuclear weapons states believe in the future that compliance is compulsory, these states can and may simply withdraw from IAEA membership and, if disarmed, rebuild nuclear weapons. Furthermore, this risks a Type IV error because these states might distrust the efficacy of existing or future international agreements if other states begin withdrawing from the NPT or the IAEA Charter. This risk of Type IV error is heightened during the early stages of the simulation when Security is greatly reduced. During this period, the risk of conflict or war is amplified.

Table 5.17: Problem 1 Stability Analysis End States

Component	**End State**
Security	0.99965
Maximize Profits	0.999909
Int'l Verification: Abolition	0.25
NGOs: Abolition	0.999986
Stories that Sell	1
NPT States: Abolition	0.999819
Religious Leaders: Abolition	0.999998
Reputation	1
Defense	0.986614
Military Capability	0
Diplomacy	0
ROI Gains	0
Nuclear Weapons	0
Conventional Weapons	0
International Investments	0
Avoid Threats	0
Proper Response	0
Self-Restraint	0.986614
Proper Treatment of Citizens	0.986614
Conformity	0.986614
Transparency	0
Attraction	0.998894
International Agreements	0
Risk of Nuclear Terrorism and Human Error	0
Behavioral Norms	0.986614
Cooperation	0
Anarchy	0
Conflict	0
Uncertainty	0
Re-Proliferation Capabilities	0
Safeguards Improvements	0

The preceding simulation is not necessarily a solution to the mess; rather, it exists to determine whether or not the system is stable enough to warrant action. This solution might

cause a Type IV error. For example, nuclear weapons states' goal of security is strongly improved by forcing transparency on nations; however, it might undermine Problem 2 by taking the question of sovereignty away from states; therefore, the following chapters will build more complexity to the mess, allowing further analysis. Although movement is towards acting to achieve goals, more understanding of the mess is necessary before a discussion on actual action is possible.

5.8 Summary

This chapter tackles the divergence between nuclear weapons states and other actors that seek to abolish nuclear weapons. It first seeks to understand stakeholder goals and how those goals interact with other stakeholder goals. It then finds that, by abstracting nuclear weapons states' goal of possessing nuclear weapons, nuclear weapons states' goal can be updated to *maximize security*. From this, numerous additional nodes are identified that form the edges of the problem, thus creating the problem in systemic terms. Finally, it is established that the system is not too mature for intervention and that it is stable enough to warrant intervention, and that it is stable enough to make intervention possible.

CHAPTER 6

PROBLEM 2

There is a disagreement as to how much international governance is necessary to ensure verification of online, peaceful nuclear programs.

6.1 Problem 2 Articulation

Recognizing the potential threat nuclear technology poses on a global scale, particularly the prospect of rapid proliferation, the IAEA was established in 1957. The IAEA's mission is to ensure the safety and promotion of peaceful nuclear technologies while further ensuring nuclear materials[302] are not diverted to weapons programs. While membership in the IAEA is high, and while even nuclear-armed states have signed agreements with the intergovernmental organization, even to the extent of agreeing to make good faith progress towards upholding the disarmament provisions of NPT Article VI, compliance is not universal. As will be discussed below, many states fall under Comprehensive Safeguards Agreements with the Additional Protocol (AP), while the Permanent Five members of the Security Council—China, France, the UK, the US, and Russia (from here on referred to as P5)—have voluntary offer agreements—meaning, these states decide what the IAEA does and does not have jurisdiction over. Furthermore, some states fall completely outside IAEA and NPT jurisdiction. In other words, cooperation with the IAEA ranges from zero to a number below 100 percent.

Here, a dialectic takes shape. Recognizing that universal IAEA jurisdiction cannot be compelled on the P5 or any state wishing to merely withdraw from IAEA jurisdiction, the IAEA has to balance global security needs with the security needs of individual states. If the IAEA and

[302] "Nuclear materials" refer explicitly to Uranium, Plutonium, and Thorium. Non-fissile radiological materials fall outside the scope of IAEA safeguards.

the NPT wish to prevent proliferation or promote international equality, they must give states the legal authority to proliferate because binding agreements that permanently prevent proliferation are unlikely to be signed and, therefore, undermine the non-proliferation regime. That is, carrying a big stick is not an attractive way to promote the nonproliferation brand. Therefore, the IAEA cannot demand every member state have strict obligations. The legal authority to withdraw from the NPT is expressly provided in Article X.

Adding further complication to this problem is the inherent dialectic within the nuclear weapons states, a reality that complicates the problem's realist foundation. In summary, these states have the potential to both threaten and cooperate with the nonproliferation regime and the IAEA's mission. For example, while the UK has the highest levels of transparency among the P5 states, France and China have almost no transparency of their weapons program.[303] Additionally, even within international agreements sit complicated realities that undermine the nonproliferation regime and the IAEA. For example, the bilateral Strategic Offensive Reductions Treaty (SORT) between the US and the Russian Federation, which sought to reduce both sides' nuclear arsenals by 50% by 2012, did not mention exactly how many weapons were to be eliminated, and it did "not require the destruction of these weapons, [did] not include tactical nuclear weapons and [did] not have any verification provisions. Additionally, the process is neither irreversible, not transparent."[304] The 2011 New Strategic Arms Reduction Treaty (New START)—at face value—attempts to overcome many of the verification limits set forth by SORT; however, it implicitly feeds into this problem because its verification depends on each state's own intelligence services rather than intergovernmental oversight. The New START's

[303] Waheguru Pal Singh Sidhu, "Nuclear Proliferation," in *Security Studies: An Introduction*, ed. Paul D. Williams (New York, NY: Routledge, 2008): 367.
[304] "Nonproliferation and Disarmament Go Hand in Hand" *International Herald Tribune*, September 22, 2004, quoted in Sidhu, 367.

national technical means of verification (NTM) are—as the name implies—technical rather than legal. Furthermore, while being a key provision in New START for the US and the Russian Federation, NTM uses universal intelligence techniques that can gather information on non-parties to the treaty, reducing non-party states' cooperative option.

The nonproliferation regime is a large voting bloc of states that adhere primarily to the NPT, in addition to several historical and current treaties and other tools that either implicitly or explicitly seek the total abolition of nuclear weapons. These are identified in Table 6.1.

Table 6.1: Nonproliferation Regime Tools

Year	Active?	Treaty/Regime	Purpose
1963	Yes	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, abbreviated as Partial Test Ban Treaty (PTBT)	Limitation of nuclear weapons testing
1970	Yes	Treaty on the Non-Proliferation of Nuclear Weapons (NPT)	Nonproliferation and disarmament
1972	No	Strategic Arms Limitation Talks Agreement (SALT I)	Arms control
1972	No	Anti-Ballistic Missile Treaty (ABMT)	Limitation of anti-ballistic missile (ABM) systems
1974	Yes	Threshold Test Ban Treaty (TTBT)	Explosive yields limitation on testing
1979	No	Strategic Arms Limitation Talks Agreement (SALT II)	Arms control
1988	Yes[305]	Intermediate-Range Nuclear Forces Treaty (INF Treaty)	Arms control and disarmament
1994	No	Strategic Arms Reduction Treaty (START I)	Arms control
1996	No	Comprehensive Nuclear-Test-Ban Treaty (CTBT)	Limitation of nuclear weapons testing
2000	No	Strategic Arms Reduction Treaty (START II)	Arms control
2003	No	Strategic Offensive Reductions Treaty (SORT)	Strategic nuclear disarmament

[305] At the time of writing the treaty is active; however, in October 2018, the US made clear its intention to withdraw from the treaty.

2011	Yes	Strategic Arms Reduction Treaty (New START)	Strategic nuclear disarmament
2017	No	Treaty on the Prohibition of Nuclear Weapons, also known as the Nuclear Weapon Ban Treaty (NWBT)	Disarmament
NA	No	Fissile Material Cutoff Treaty (FMCT)	Prohibition of militarized fissile material production
NA	No	Strategic Arms Reduction Treaty (START III)	Arms control
1974	Yes	Nuclear Suppliers Group (NSG)	Nonproliferation and fissile material export control
1987	Yes	Missile Technology Control Regime (MTCR)	Nonproliferation and missile technology export control
1957	Yes	International Atomic Energy Agency (IAEA)	Nonproliferation and disarmament
NA	Varies	Nuclear-weapons-free zone (NWFZ)	Nonproliferation and prohibition on testing and deployment

While many of these tools are toothless, they represent a growing consensus in the international community that nuclear weapons are outside acceptable international standards of decency. The nonproliferation norm is largely a product of non-realist recognition of nuclear weapons' destructive capability. Essentially, deterrence does not play into the nonproliferation regime's calculus; rather, the utilization of these tools comes from the normative position that using nuclear weapons is unacceptable.[306] As Lüthi pointed out in the previous chapter, this norm is so pervasive that NPT states view it as their moral obligation to participate in the dialectic between nuclear weapons states and international verification agencies.[307]

Presently, the IAEA operates between severely limited and approaching total jurisdiction within willing member states. Outside this spectrum the IAEA has no jurisdiction. For example,

[306] Tannenwald, 433.
[307] Lüthi, 98.

it has no authority to verify the safety and non-militarized use of nuclear materials in North Korea.[308]

According to the IAEA's "Safeguards and verification" website and sub-websites, accessed June 2018.[309] IAEA safeguards evolve alongside technological improvements and the commissioning or decommissioning of facilities, which increase the number of individual verifications of materials. As of 2015 the IAEA has safeguard plans in effect for 181 states (and Taiwan) with APs in place for 127 states (and Taiwan), consisting of over 1,200 facilities. The AP covers enough nuclear materials to build about 200,000 nuclear weapons. To verify this quantity of materials, in 2015 the IAEA conducted over 2,000 in-field inspections, over 600 verifications of design information, and over 60 complementary facility accesses, generating almost 800,000 reports and totaling over 13,000 calendar days' worth of work. This work requires a staff of almost 900 employees (including about 90 contractors) and an annual budget (in 2015 rates) of about €175,000,000. In 2014 the IAEA retained 89.5% of its pledged payments.[310]

IAEA safeguards are set up to ensure safe and peaceful use of nuclear components, systems, and materials. They are tools to verify states' legal obligations and go through an annual cycle[311] consisting of four processes. First, safeguard-relevant information is collected and verified for consistency. Second, a safeguards approach is developed. Third, the IAEA conducts the evaluation to identify potential inconsistencies. Finally, the IAEA draws up its

---

[308] Although, it can be argued that the IAEA maintains its authority because the DPRK's withdrawal did not completely abide by the provisions of NPT Article X.
[309] "Safeguards and verification," International Atomic Energy Agency, last modified February 2018, https://www.iaea.org/topics/safeguards-and-verification.
[310] Yukiya Amano, *Technical Cooperation: Report for 2014* (Vienna: International Atomic Energy Agency, 2015), https://www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-3_en.pdf.
[311] This annual cycle is captured in the *when* section.

safeguards conclusions. After this cycle is complete the IAEA releases its report to the UN General Assembly, and, if necessary, the Security Council, as well as a version to the general public.

In order to collect and verify information, the IAEA relies on three primary methods: state-provided information, self-collected information, and information received via other means, such as through third parties or open sources (represented in the *how* section). Over 170—or the majority of—agreements between states and the IAEA are Comprehensive Safeguards Agreements (CSA), meaning these states agree to allow relatively robust verification of their nuclear energy programs.[312] In these states any anomalies with their self-reported information can be dealt with through legal measures. The P5 fall under voluntary offer safeguards agreements, which means these states can decide without IAEA input which facilities can be monitored. Three nuclear weapons states not party to the NPT—Israel, India, and Pakistan—have item-specific agreements with the IAEA, often only on imported materials. 127 countries have signed the Additional Protocol, a development seen as necessary to strengthen the IAEA's ability to ensure materials are not diverted to weapons programs.[313] The IAEA deemed this necessary after safeguards failures in Iraq and North Korea during the early 1990s.

To develop a safeguards approach, the IAEA looks at state-specific systems, capabilities, and materials and attempts to determine any viable avenues for using these items to develop weapons, an approach referenced later, called the acquisition pathway analysis (APA). These are usually technical in nature and require technical expertise.

---

[312] It needs to be noted here that "comprehensive" does not mean the IAEA holds a monopoly over the individual state's nuclear program. Defection is possible even under the CSA. For example, a state could sign the CSA, declare sites, and merely maintain clandestine sites away from IAEA scrutiny, which was the method Iraq used prior to the Persian Gulf War.

[313] The P5 each have APs in place; however, the AP does not provide the IAEA with CSA-like authority in the P5 states. A description of how the AP works is provided in the *how* section.

To develop a safeguards and verification plan, the IAEA builds off the individual safeguards approach, using a variety of tools for in-field and off-site inspections and analyses. These include bookkeeping similar to the banking industry, environmental sample analyses, destructive or non-destructive assays of nuclear materials,[314] and containment and surveillance techniques, among others. Combined, these efforts help build a "continuity of knowledge" over the state's nuclear materials. Furthermore, these techniques provide some measure of detection of undeclared materials, facilities, or operations because anomalies in the continuity of knowledge emerge.

Finally, each year the Board of Governors releases its Safeguards Implementation Report, a detailed analysis and conclusions drawn from information collected from safeguard plans. The conclusions drawn are state-specific and vary according to the state's individual safeguard agreement. These are detailed in Table 6.2.

Table 6.2: IAEA Safeguard Conclusions (quoted in their entirety)[315]

Safeguards Agreement Type	Conclusion Type
CSA with Additional Protocol	• *If the IAEA's Secretariat has completed all evaluations and found no indication of the diversion of declared nuclear material from peaceful activities and no indication of undeclared nuclear material or activities for the State as a whole, the Secretariat concludes that all nuclear material remained in peaceful nuclear activities; and* • *If the Secretariat found no indication of the diversion of declared nuclear material from peaceful activities, but evaluations regarding the absence of undeclared nuclear material and activities remained ongoing, the Secretariat concludes, on that basis, that declared nuclear material remained in peaceful activities.*
CSA without	• *If the IAEA's Secretariat found no indication of the diversion of*

[314] These are radiation measurement techniques. Destructive assays destroy the sample but provide results with much higher confidence.
[315] "Drawing safeguards conclusions," International Atomic Energy Agency, last modified 2017, https://www.iaea.org/topics/drawing-safeguards-conclusions.

Additional Protocol	*declared nuclear material from peaceful activities the Secretariat concludes that declared nuclear material remained in peaceful nuclear activities.*
Under Item-Specific Safeguard Agreement	• *If the IAEA's Secretariat found no indication of the diversion of nuclear material or of misuse of the facilities or other items to which safeguards had been applied, the Secretariat concludes that nuclear material facilities and other items to which safeguards had been applied remained in peaceful activities.*
Voluntary Offer Safeguard Agreement	• *If the IAEA's Secretariat found no indication of the diversion of nuclear material to which safeguards had been applied, the Secretariat concludes that nuclear material to which safeguards had been applied in selected facilities was not withdrawn from safeguards, except as provided for in the agreements, and remained in peaceful activities.*
No Agreement	• *For States with no safeguards agreements in force, the IAEA Secretariat cannot draw any safeguards conclusions.*

Additionally, the IAEA has other agendas for preventing malicious nuclear programs. For example, it provides states with radiological detection capabilities and training to identify illicit movement of radiological materials across their borders. When a state's safeguards and detection equipment needs updating the IAEA provides member states with necessary upgrades.

These techniques exemplify the problem. The IAEA could operate with guaranteed efficiency in a world where the IAEA was a Hobbesian and monolithic agency with perfect jurisdiction over all member states. In reality the P5 and other nuclear weapons states can simply deny the IAEA access to materials or systems they do not wish the IAEA to see. Indeed, all member states can simply withdraw from the IAEA, reducing its jurisdiction to zero. Not desiring defection from the regime, the IAEA must balance the needs of its mission with member states' individual needs under legal sovereignty. In other words, how much cooperation with the IAEA is necessary to maximize international nuclear safeguards and governance, and how much are states willing to cooperate? To illustrate this problem, the 2011 nuclear incident at the

Fukushima Daiichi nuclear power plant sparked a debate about how much jurisdiction the IAEA should have over nuclear materials. While all parties, including the Japanese Diet, desire stronger safeguards to mitigate the risk of another event like the one at Fukushima, some states wish to nationalize, rather than internationalize, jurisdiction over nuclear reactors,[316] meaning cooperation has not been maximized.

Table 6.3: Problem 2 Stakeholders

Stakeholder	**Description**
NWs states	Nuclear-armed states as unitary actors, comprising the P5.
International verification and compliance agencies	These are international organizations that encourage peaceful use of nuclear materials, administer safeguards to ensure compliance, and work to prevent nuclear proliferation (for example, the IAEA).
NGOs and activists	These are groups of civilians that actively promote nonproliferation and disarmament (examples include ICAN, Greenpeace, etc.).
Media	These are groups or individuals that spread information through various communication methods (e.g., television, radio, print, social media).
NPT states	These are signatory states in good standing in accordance with the NPT, which includes most recognized states not previously identified as nuclear weapons states[317] and major UN voting blocs, such as the non-aligned movement[318].
Religious leaders	These are influential individuals of various faiths that can sway public opinion from the pulpit.
Outlier States	These are the four remaining nuclear-armed states, including the DPRK, India, Israel,[319] and Pakistan.

[316] For an in-depth discussion on the debate see Norbert Pelzer, "Safer Nuclear Energy through a Higher Degree of Internationalisation?: International Involvement versus National Sovereignty," *Nuclear Law Bulletin*, no. 1 (2013): 43-88.
[317] At the time of writing, South Sudan is the only non-signatory and non-nuclear weapons state.
[318] Excluding Pakistan, India, and North Korea (as members of NAM), as well as China (as an observer state). These are nuclear weapons states.
[319] Little is known about Israel's nuclear weapons program. Israel might fall under the Nuclear Weapons States category.

6.2 Problem 2: Who?

In this section the same methodology applies from Problem 1. Stakeholders in the mess and its constituent problems are identified in Table 6.3. Table 6.4 identifies stakeholder wants.

Table 6.4: Problem 2 Stakeholder Wants

Stakeholder	**Want**
NWs states	Maximize sovereignty
International verification and compliance agencies	Maximize cooperation
NGOs and activists	Oversight
Media	Stories that sell
NPT states	Participation
Outlier states	Prestige[320]

Each nuclear-armed state has two broad verifiable components: nuclear weapons and other nuclear material programs. While on the one hand they want to maximize their sovereignty, they also have interest in other states' increased cooperation in verification and compliance. For the purpose of this section, NPT states are inherently compliant[321] and seek nuclear equality among states (disarmament and the right to technology). The NPT states therefore seek serving as directors or deputy directors general, in policymaking, in oversight, in legal, in technical, and in other services, including onsite inspection teams. NGOs desire oversight. The media maintains its desire to find stories that sell. International verification and compliance organizations want to

[320] In this sense, Outlier States are asserting that the international community cannot tell it what to do and that they desire to be seen as equal to the nuclear powers.
[321] Some states cannot be compliant in the real world system; however, their present situation precludes them from participating. Syria, for example, is presently out of good standing with the IAEA, but Syria does not have the resources to take part in the IAEA's mission.

maximize their ability to verify compliance. The IAEA's mission, for example, is to ensure the peaceful civil use of atomic materials. In order to accomplish this, states must cooperate with inspectors. Production firms, religious leaders, and the environment are excluded from this section; however, their role is not null; they take on a minor level of ownership along the edges of Problem 2 (for the Environment, their role becomes clearer later). Finally, a new stakeholder must be introduced; Outlier States are states that possess nuclear weapons, are largely inactive (they tend to ignore the problem), demonstrate potential to threat, and fall under less-than-average IAEA jurisdiction. These states include India, Israel, North Korea, and Pakistan. While this project seeks to follow realist tenets as much as possible, outlier states cannot be ignored, and this project therefore continues to adopt the "realist plus" position, as exemplified by Sagan, where less-secure states face higher threat for losing control of nuclear arsenals.[322]

Table 6.5: Problem 2 Stakeholder Classification

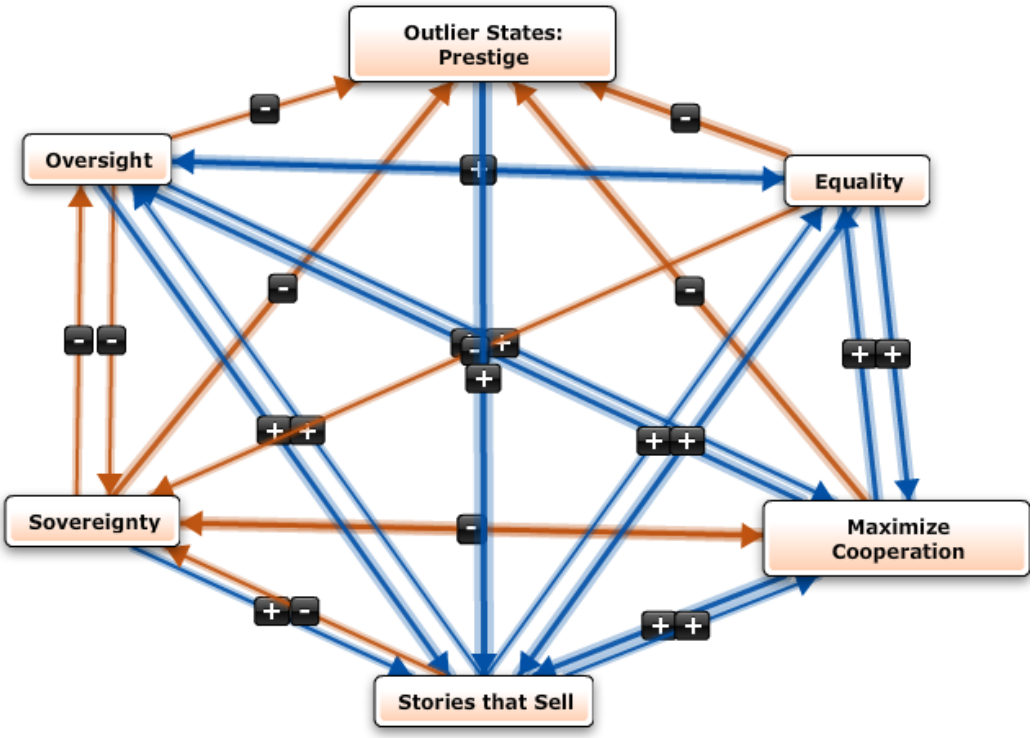
Stakeholders	Power	Legitimacy	Urgency	Prominence	Class	Classification
NWs States	1	1	1	1.00	Definitive	Definitive
International verification and compliance agencies	1	1	1	1.00	Definitive	Definitive
NGOs and activists	0	1	1	0.67	Dependent	Expectant
Media	0	1	0	0.33	Latent	Discretionary
NPT states	1	1	1	1.00	Definitive	Definitive
Outlier states	1	1	0	0.67	Dominant	Expectant

[322] Sagan and Waltz, 49.

Table 6.6: Problem 2 Stakeholder Attitudes and Strategies

Stakeholders	Threat	Cooperate	Support	Attitude	Strategy
NWs States	1	1	0	Mixed	Collaborate
International verification and compliance agencies	0	1	1	Supportive	Involve
NGOs and activists	0	1	1	Supportive	Involve
Media	0	0	0	Marginal	Monitor
NPT states	0	1	1	Supportive	Involve
Outlier states	1	1	0	Mixed	Collaborate

Figure 6.1: Problem 2 FCM Who



Stakeholder Management Plan

Table 6.7: Problem 2 Stakeholder Management Plan

Concept	**Strategy**	**InDeg**	**OutDeg**	**Activity**	**Popularity**	**Engagement Priority**
Cooperation	Involve	1.5	3	3.872983	2.44949	1
Equality	Involve	1.25	2.5	3.535534	1.936492	2
Oversight	Involve	1.75	1.5	2.738613	2.645751	3
Sovereignty	Collaborate	1.25	1.25	2.236068	2.236068	4
Stories that Sell	Monitor	2.75	1	2	3.708099	5
Outlier States	Collaborate	1.75	1	1	2.645751	6

Table 6.8: Problem 2 Who Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Sovereignty	Nuclear Security	-0.25	NWS do not relinquish sovereignty by merely signing IAEA agreements (hence IAEA Charter Article XVIII and NPT Article X); however, this negative relationship between states seeking sovereignty and the IAEA's goal of securitizing global nuclear programs is weak because member states, even NWS, are generally willing to participate and contribute.
Sovereignty	Oversight	-0.25	NGOs are less able to function because states can simply ignore them; however, this relationship is weak because states and publics tend to work with them. It is only when national security becomes the issue that NGOs' goal of oversight is weakened.
Sovereignty	Stories that Sell	0.25	Anything the state does for national security purposes is generally a news worthy event; however, this relationship is weak because the media reports on a wide range of topics.

Sovereignty	Outlier States	-0.5	NWS national security goals moderately reduce Outlier States' goal of prestige because of sanctions or other actions that treat Outlier States as pariahs. This relationship does not graduate to 'strong' because the behavior is not universal. Israel's NWs program has not been heavily scrutinized, and the US amended its law to allow civil nuclear trade with India.
Nuclear Security	Sovereignty	-0.5	The IAEA moderately diminishes NWS sovereignty by design; however, it cannot impose order over states (they can simply withdraw).
Nuclear Security	Oversight	0.75	Much of what NGOs do requires access to unclassified state-level information. The IAEA, through its inspections and communications, makes much of this information available for public scrutiny.
Nuclear Security	Stories that Sell	0.5	The IAEA moderately increases the media's goal through public communications. This relationship is larger than NWS ability to increase the media's goal because the IAEA is purposely communicating with an international audience.
Nuclear Security	Equality	0.75	This relationship is strong because the IAEA collates and redistributes technology and knowledge to developing nations that desire to build non-militarized nuclear programs.
Nuclear Security	Outlier States	-0.5	The IAEA moderately diminishes Outlier States goal of prestige by communicating its inability to confirm activities. Further, the IAEA's mission is according to the NPT, which no Outlier State has signed, violating international norms.
Oversight	Sovereignty	-0.25	NGOs diminish NWS ability to function as desired by involving itself in politics and pressuring states and constituents. This relationship is weak because even democratic states can simply ignore them.
Oversight	Nuclear Security	0.25	NGOs can supplement small portions of the IAEA's mission by acting as a surrogate between the IAEA and states (political pressure to take the IAEA seriously) and involving itself as nuclear watchdogs. This relationship is weak because NGOs do not have large resources.
Oversight	Stories that Sell	0.5	This is a moderate relationship because NGOs generally depend on the media to disseminate their message; however, the relationship is not strong due to the media's ability to decide what to report

Oversight	Equality	0.25	NGOs can support NPT states' goal of equality by publicly stating their support or actively working with developing states; however, this relationship is weak due to limited budgets.
Oversight	Outlier States	-0.25	This relationship is similar to the relationship between NGOs and NPT states, but it is a negative relationship.
Stories that Sell	Sovereignty	-0.25	The media can sway how NWS interact by publicizing domestic and international behaviors to domestic and international audiences; however, this relationship is weak because much of political maneuvering happens behind closed doors.
Stories that Sell	Nuclear Security	0.25	The media plays a small role in the IAEA's mission by acting as a conduit between the IAEA and audiences.
Stories that Sell	Oversight	0.25	The media plays a small role in NGOs' mission by providing information to the NGOs and by transferring NGOs' messages to audiences.
Stories that Sell	Equality	0.25	The media tends to support NPT states; however, this relationship is weak because it can ignore NPT states, depending on news stories of the day.
Stories that Sell	Outlier States	0	This relationship is null because the media equally reports on positive and negative information about the states.
Equality	Sovereignty	-0.25	NPT states place pressure on NWS to promote equality; however, ultimately, NWS cannot be compelled.
Equality	Nuclear Security	0.75	This relationship is strong because ultimately the IAEA cannot function without a preponderance of international support, which, as the largest voting bloc, the NPT states provide.
Equality	Oversight	0.5	This relationship is moderate because NPT states can provide information to NGOs and support NGO missions.
Equality	Stories that Sell	0.5	This relationship is moderate because NPT states' activities provide a wealth of stories to the media. It is not strong because the media can report on other matters at its discretion.
Equality	Outlier States	-0.5	This negative relationship is moderate because NPT states create a norm that Outlier States violate by not fully participating in the NPT and the IAEA; however, Outlier States are not strongly diminished by failing to participate.

Outlier States	Stories that Sell	1	Regardless of whether or not the stories are positive or negative, Outlier States are regularly in the headlines (e.g. no matter what the story is about, the media enjoys reporting on the DPRK).

Problem 2 Stakeholder Management

The results are counterintuitive, as will be seen below. Generally, especially given realist logic, state interests should precede non-states' or intergovernmental agencies' interests. These results suggest international verification and compliance agencies are very active and are facing low external stakeholder pressure. Their interests take precedence to states' interests. As supportive stakeholders these agencies, NPT states, and NGOs involvement should be prioritized. Media should be monitored for stories that will increase support from non-supportive states. States, including Outlier States, must be involved because involvement creates a sense of urgency and increases future cooperation toward resolving the nuclear weapons dialectic.

6.3 Problem 2: What?

Problem 2 Objective Narrative

Recalling that international verification and compliance agencies are the prioritized stakeholders, the problem is that there is debate about how much cooperation is necessary to be in good standing with the agencies. The IAEA, whose authority to verify compliance comes through Article III of the NPT, does not have the power to compel compliance beyond publicly exposing uncooperative behavior. Furthermore, as identified in Problem 1, running afoul of the NPT (such as North Korea defecting) merely runs the risk of sanctions, while regaining total

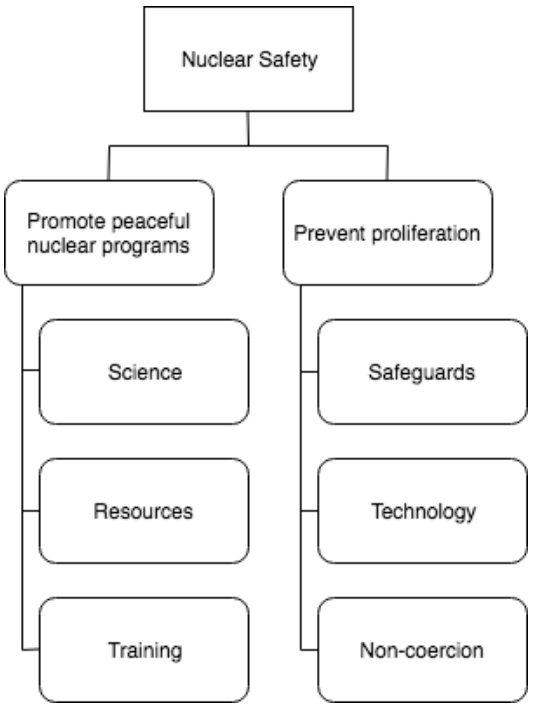
nuclear sovereignty if IAEA membership is withdrawn. Therefore, the IAEA needs to find a universally acceptable balance between zero verification and total verification.

International verification and compliance agencies' primary goal, as identified in the previous section, is to maximize cooperation with the NPT states and IAEA member states and that they are in compliance with safeguard provisions of the NPT that prevent peaceful nuclear materials from being diverted to non-peaceful nuclear programs. Alternately, the IAEA seeks to balance objectives to promote peaceful nuclear programs and prevent proliferation. Taken together these goals can be called, for the purpose of this project, *nuclear security*.

Problem 2 Fundamental Objectives Hierarchy

As identified above, international verification and compliance agencies' primary goal is *nuclear security*, which is the promotion of peaceful nuclear energy programs; such as energy, medical, agricultural, and other programs; and the prevention of military uses of nuclear technology (often called "dual use"). The fundamental objectives hierarchy reveals that to promote peaceful nuclear programs, the IAEA can and does invest in science, provide resources, and provide training. To prevent proliferation of militaries or non-state actors, the IAEA can and does institute safeguards that are more or less verifiable, provide securitizing technology to states, and make requirements to use non-coercive techniques. These are illustrated in Figure 6.2.

Figure 6.2: Problem 2 Fundamental Objectives Hierarchy



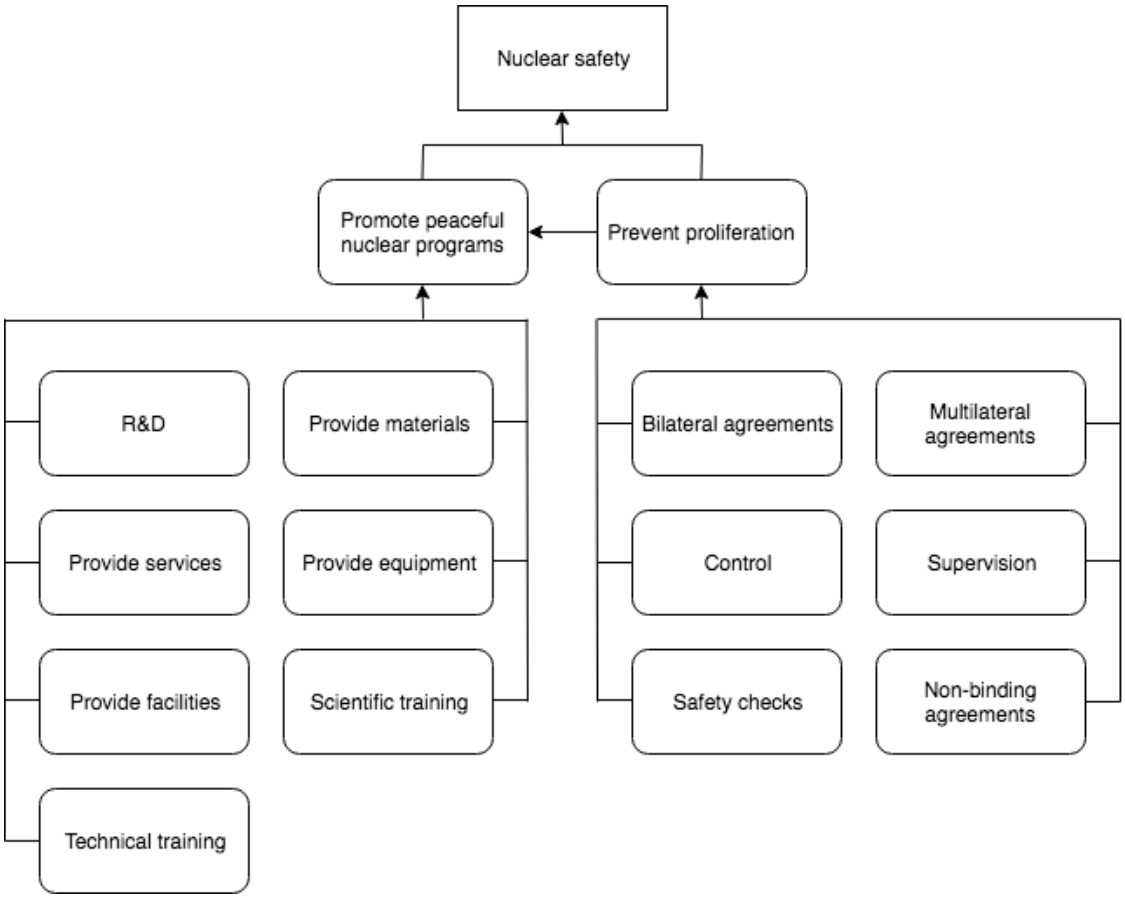
Problem 2 Means-Ends Network

Ensuring nuclear security has two fundamental objectives: *Promotion of peaceful nuclear programs* and *prevention of proliferation*. Promotion of peaceful nuclear programs means investments in research and design programs and providing materials, services, equipment, facility access, scientific training, and technical training to member states desiring to participate in nuclear programs.[323] Preventing proliferation means promoting bilateral and multilateral agreements, tight control and supervision over nuclear materials, and conducting safety and security checks (or inspections) of facilities. An important means to ensuring nonproliferation is

[323] From the perspective of developing states within the NPT, this has the added benefit of serving as a means for wealth redistribution, thus progressing the goal of equality among nations. See Benjamin Schiff, "Dual Mandate: Safeguards and Technology Transfer in the International Atomic Energy Agency," (PhD diss., University of California, Berkeley, 1982): 2.

to make all agreements non-binding. States should be free to withdraw from any agreement without consequence.[324] Coercive treaties and agreements are not as attractive to potential signatories as non-binding treaties or agreements. Finally, preventing proliferation is a means by which to promote peaceful nuclear programs because proliferation can beget proliferation. These tools are reflected in Figure 6.3.

Figure 6.3: Problem 2 Means-Ends Network



[324] For example, sanctions against the DPRK following its defection might have reinforced its belief that the West cannot be trusted, making it more difficult to get them back to international norms.

Table 6.9: Means-Ends Network Node Identifiers

Promote peaceful nuclear programs	This is a goal for which the IAEA strives.
R&D	The IAEA, alongside individual states' safeguards programs, conducts research and design in order to develop better detection, monitoring, and analysis capabilities.
Provide materials	Materials are nuclear materials necessary to run nuclear programs that are beyond the indigenous reach of some member states.
Provide services	Service is administrative assistance covering member states' indigenous R&D, training, and accounting of materials and technology.
Provide equipment	Equipment is the physical technical components necessary to run nuclear programs.
Provide facilities	Facilities are areas designated by the IAEA and member states that serve to provide R&D, training, and other activities.
Scientific training	Scientific training is advanced-level training that enables scientists to engage in R&D.
Technical training	Technical training is advanced-level training that enables engineers, scientists, and other practitioners to engage in R&D.
Prevent proliferation	This is a goal for which the IAEA strives.
Bilateral agreements	These are agreements between two states. For the purpose of this research, these agreements are security related but do not necessarily fall under the purview of the IAEA.
Multilateral agreements	These are agreements between three or more states, usually security-related, falling under IAEA purview.
Control	Export control is the regulation of materials and components that have dual use capability.
Supervision	Supervision is the regulatory oversight of nuclear material site design, construction, and operation.
Safety checks	Safety checks include safeguards inspections, as well as the testing, maintenance, and inspection of facilities, materials, and practices.
Non-binding agreements	Non-binding agreements are included as a means by which to attract member states to the regime. These agreements, such as NPT Article X, assure member states that continued cooperation is not compulsory and therefore encourages participation.

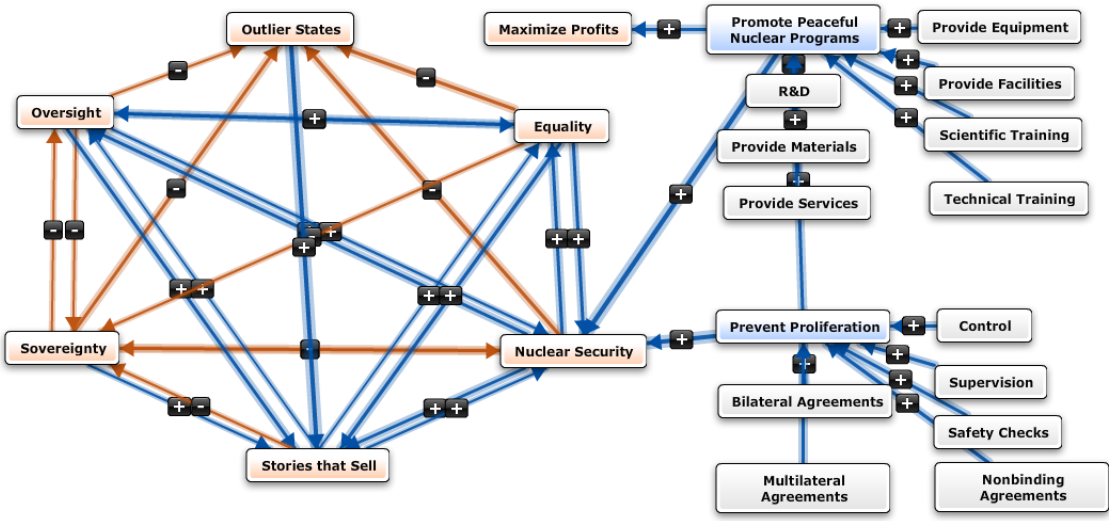
Problem 2 What FCM

Applying the means-ends network and international agencies' updated problem statement to Problem 2's FCM shows emergence of new links between *who* and *what*. Most noticeably is that production firms, stockholders, and NPT states benefit greatly from the scientific knowledge

and resources provided by the promotion of peaceful nuclear programs. Research and design negatively affects the environment to a moderate degree.[325] On the proliferation prevention side, safety checks moderately increase the environment because they help prevent the release of materials that can be detrimental to the ecosystems. Bilateral and multilateral agreements have a moderate positive effect on media's ability to sell stories. Finally, control and supervision over nuclear materials and components as well as safety checks have a moderate negative effect on nuclear weapons states' goal of maximizing sovereignty.

An additional point, here Nonbinding Agreements should positively and strongly affect Problem 1's Re-Proliferation Capabilities. This is reflected along the edges of the problem.

Figure 6.4: Problem 2 FCM What



[325] Identifying the Production Firms' and Stockholders', as well as the environment's, links also exposes overlap between Problems 1 and 2, which is therefore modeled along Problem 2's edges.

Table 6.10: Problem 2 What Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Promote Peaceful Nuclear Programs	Nuclear Security	1	This relationship is very strong. As states seek technology, they become wedded to the IAEA's mission if they are working through IAEA channels. This helps perpetuate non-nuclear proliferation.
Promote Peaceful Nuclear Programs	Maximize Profits	0.75	As states decide to build, maintain, or expand peaceful nuclear programs, production firms and stakeholders benefit from contract awards and increased stock prices.
Promote Peaceful Nuclear Programs	The environment	-0.5	Increased production is moderately harmful to the environment.
Prevent Proliferation	Nuclear Security	1	This is self-explanatory. An increase in proliferation prevention has a commensurate increase in nuclear security.
Prevent Proliferation	Promote Peaceful Nuclear Programs	0.5	This relationship is moderate. By putting into place mechanisms to prevent proliferation, the IAEA acknowledges that states have an inherent right to peaceful technology.
R&D	Promote Peaceful Nuclear Programs	0.5	R&D moderately increases peaceful nuclear programs by decreasing the costs associated with high tech systems.
Provide Materials	Promote Peaceful Nuclear Programs	0.5	The IAEA, through member states, can provide materials to states seeking peaceful nuclear programs. This relationship is moderate because not all states choose to adopt nuclear programs.
Provide Services	Promote Peaceful Nuclear Programs	0.5	See above.
Provide Equipment	Promote Peaceful Nuclear Programs	0.5	See above.
Provide Facilities	Promote Peaceful Nuclear Programs	0.5	See above.
Scientific Training	Promote Peaceful Nuclear Programs	0.5	See above.

Technical Training	Promote Peaceful Nuclear Programs	0.5	See above.
Bilateral Agreements	Prevent Proliferation	0.5	By helping to facilitate bilateral technology transfers, the IAEA can oversee nuclear programs to ensure the technology is only being used for peaceful purposes.
Multilateral Agreements	Prevent Proliferation	0.5	See above.
Control	Prevent Proliferation	0.5	Export control moderately increases proliferation prevention. It does not graduate to strong because states can circumvent control measures.
Supervision	Prevent Proliferation	0.5	By supervising the design, construction, and operation of facilities, proliferation prevention is moderately increased. It does not graduate to strong because states can have clandestine sites.
Safety Checks	Prevent Proliferation	0.75	Inspections increase proliferation prevention by deterring states from clandestine operations or material diversions; however, it does not graduate to very strong because inspections are not perfect.
Nonbinding Agreements	Prevent Proliferation	0.5	These agreements moderately increase proliferation prevention by enticing states to join, giving them a future opt-out ability. It is not strong because states can join, refrain from withdrawing, and still pursue nuclear weapons (see Libya and Iraq, for example)
Nonbinding Agreements	Re-proliferation capabilities	0.75	This relationship is strong because states can enter agreements to disarm, withdraw, and re-proliferate under legal frameworks. This node is not a part of Problem 2 and is only included along the edges because it exposes overlap between Problems 1 and 2.

6.4 Problem 2: Why?

Problem 2 Motivation and Feedback Analysis

The first thing that becomes immediately obvious is a triadic closure between the Nuclear Security, Stories that Sell, and Prevent Proliferation nodes. That is, as Prevent Proliferation increases, Nuclear Security increases. As Nuclear Security Increases, Stories that Sell increase (the IAEA makes a press release). Finally, as Stories that Sell increase, Prevent Proliferation increases (would-be cheaters are—to some degree, however large or small—deterred). Therefore, a new causal moderate link between Stories that Sell (sender) and Prevent Proliferation (receiver) is included.

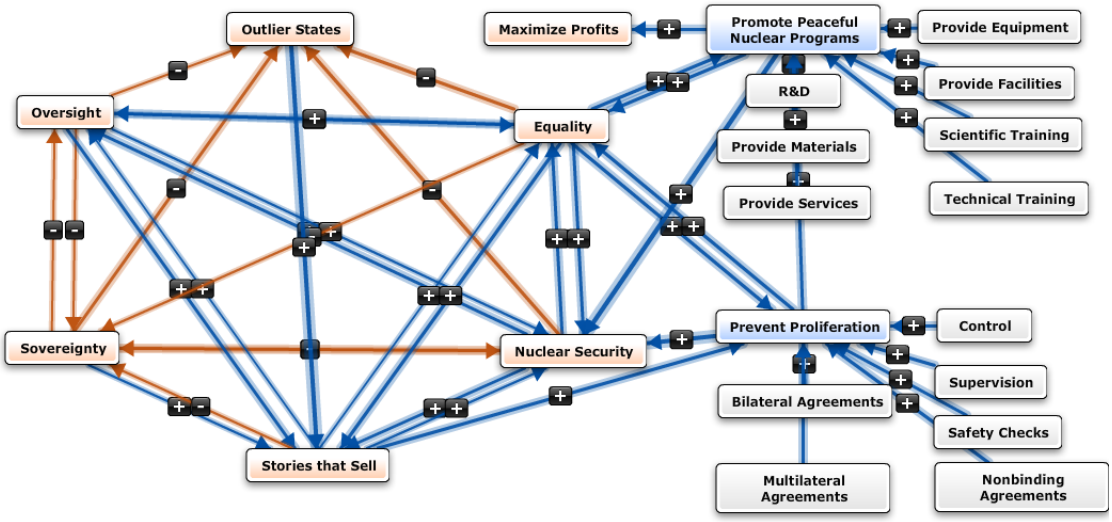
The second change is feedback loops between Equality and Promote Peaceful Nuclear Programs, as well as Equality and Prevent Proliferation. While taken together, these concepts make up the IAEA's goal of Nuclear Security, each independently and moderately affects the NPT states' goal of equality and vice versa. As states become more equal, states have better access to peaceful nuclear technology, and as access increases, equality increases. Likewise, equality increases the likelihood that proliferation will be prevented, and increased proliferation prevention increases equality.

These changes are reflected in the updated FCM.

Table 6.11: Problem 2 Why Qualitative Link Justification

Sender Component	Receiver Component	Link	Reasoning
Stories that Sell	Prevent Proliferation	0.5	The media can report to different audiences the findings of the IAEA, which helps deter states from proliferation. It does not graduate to strong because states can decide the cost of detection does not outweigh the gains of cheating.
Equality	Promote Peaceful Nuclear Programs	0.5	This relationship is moderate. NPT states can decide whether or not to seek peaceful nuclear programs.
Promote Peaceful Nuclear Programs	Equality	0.5	This relationship is moderate. NPT states can decide whether or not to seek peaceful nuclear programs.
Prevent Proliferation	Equality	0.5	See above.
Equality	Prevent Proliferation	0.5	This relationship is moderate. Generally, NPT states will not withdraw from the NPT or clandestinely seek nuclear weapons; however, NPT states cannot prevent others from withdrawing or seeking weapons.

Figure 6.5: Problem 2 FCM Why



6.5 Problem 2: Where?

As in Problem 1, this section identifies the sources of motivation, power, and knowledge.

Problem 2 Boundary Articulation

Based on further analysis of the problem's boundary, the following boundary critique is provided. The IAEA wants nuclear security. This is its motivational source; however, its ultimate function is to help nuclear weapons states navigate towards an end state where nuclear weapons are no longer necessary to increase the states' security (Problem 1) and in keeping with the provisions under NPT Article VI. Therefore, there is a need to assist all states with their respective nuclear technology programs, while being mindful of the big picture—disarmament. The primary stakeholders in this problem have relatively high levels of power—more than nuclear weapons states would prefer. This is exemplified by the fact that nuclear weapons states are not simply ignoring the problem. If non-state actors and intergovernmental organizations were powerless, nuclear weapon states could ignore them. Instead, they acknowledge power beyond the sovereign state. The IAEA and the NPT states, through mechanisms of their own, have some ability to get nuclear weapons states to do things they would not otherwise do. Nuclear weapons states, therefore, appear receptive to at least a limited amount of international cooperation, even at the cost of some measurable amount of sovereignty.

Problem 2 Context Articulation

Following the same format in Problem 1, the following elements are identified for Problem 2.

Table 6.12: Problem 2 Context Articulation

Category	Elements
Circumstances	Requirement to comply with international agreements
Factors	Uncertainty, Anarchy
Conditions	Need to bring new systems online, limited budgets
Values	States are not expected to give up sovereignty
Patterns	Established processes for verification

Table 6.13: Problem 2 Force Field Diagram

Driving Force	Strength as-is	Strength ought-to-be	Problem	Restraining force	Strength as-is	Strength ought-to-be
International Agreements	0.5	0.75	Present State: States operate under anarchy and uncertainty, which hinders the ability of the IAEA to complete its mission. Idealized State: Nuclear weapons states and outlier states should be willing to work towards upholding their commitments under NPT Article VI in transparent ways, but should not be required to give up total nuclear sovereignty	Uncertainty	-0.75	-0.25
Verification Processes	0.5	0.75		Anarchy	-0.5	-0.25
				Expectations of Sovereignty	-0.75	-0.25
				Safeguards Costs	-0.5	0.5

Similar to Problem 1, there are several competing elements in this problem. The circumstances—the requirement to comply with international regulations—and the established processes for verification work in favor of bringing this problem to solution. On the other hand, the factors of uncertainty and anarchy, as well as limited budgets, new systems coming online (which further stretch budgets), and the expectations of sovereignty hinder simple solutions.

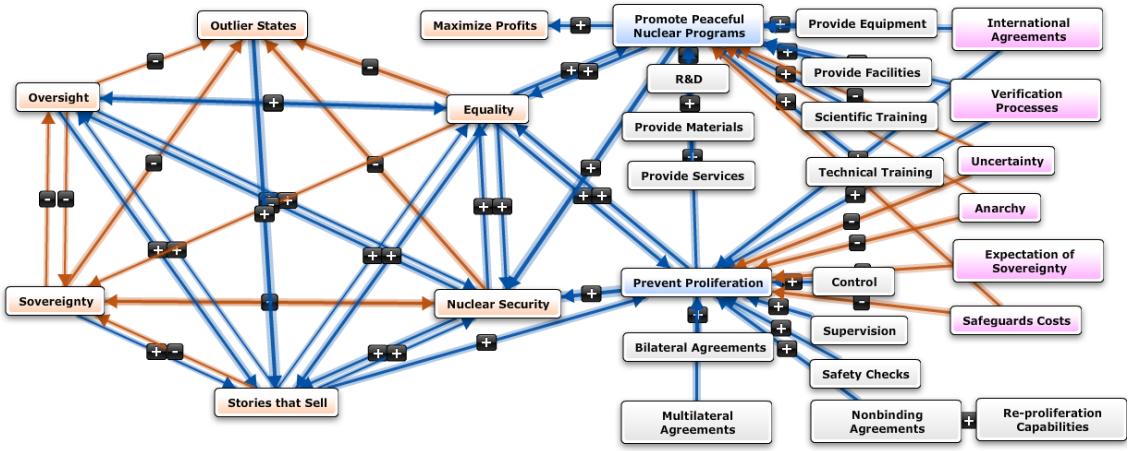
Proposed Ought-to-Be Changes

Nuclear-armed states, while presently adding to uncertainty, should exhibit more transparent behavior with the IAEA so that their nuclear systems can work towards upholding their commitments to Article VI of the NPT in a publicly verified fashion. This proposal does not call upon nuclear-armed states to give up nuclear sovereignty; rather, it seeks a decrease in uncertainty by working with the IAEA in manners similar to member states falling under some form of comprehensive, rather than voluntary offer, agreements to complement their APs. Furthermore, outlier states should follow suit (mindful that security concerns are addressed in Problem 1). All states should likewise work under IAEA guidance and observation under increased budgets to reduce existing fissile stockpiles and weapons. In short, there should be multilateral efforts made to adhere to NPT Article VI.

Table 6.14: Problem 2 Where Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
International Agreements	Promote Peaceful Nuclear Programs	0.75	This is a strong relationship because documents like the NPT and IAEA charter set the stage for peaceful nuclear program promotion.
International Agreements	Prevent Proliferation	0.75	See above.
Verification Processes	Promote Peaceful Nuclear Programs	0.5	Established processes for verification moderately increase the promotion of peaceful nuclear programs.
Verification Processes	Prevent Proliferation	0.5	See above.
Uncertainty	Promote Peaceful Nuclear Programs	-0.25	This relationship is weak because states can choose to forego programs.
Uncertainty	Prevent Proliferation	-0.75	This relationship is strong because states can choose to proliferate clandestinely.
Anarchy	Promote Peaceful Nuclear Programs	-0.25	This relationship is weak because states can choose to forego programs.
Anarchy	Prevent Proliferation	-0.5	This relationship is strong because states can choose to proliferate clandestinely.
Expectation of Sovereignty	Prevent Proliferation	-0.75	Ultimately, sovereignty as a norm means that states can proliferate as desired.
Safeguards Cost	Promote Peaceful Nuclear Programs	-0.5	The cost of internal safeguarding might be prohibitive to smaller states.
Safeguards Cost	Prevent Proliferation	-0.5	See above.

Figure 6.6: Problem 2 FCM Where



6.6 Problem 2: How?

This section addresses the means by which the international system can move beyond its present state to reach its desired state—one with synthesis between stakeholder goals. Recalling the Cynefin framework's five domains from Problem 1—known-knowns (simple), known-unknowns (complicated), unknown-knowns (complex), unknown-unknown (chaotic), and disorder—this section analyses the problem's Cynefin domain and mechanism.

Problem 2 Cynefin Analysis

Problem 2 appears to consist of order. It rests within the complicated domain and lacks unknown complexity and chaos. The problem is not, however, simple; like Problem 1 known-unknowns—uncertainty and anarchy—continue to plague the contours of the problem. Additionally, and also like in Problem 1, these uncertainties make hedging or cheating ongoing problems. While cheating is more difficult to mitigate, nonbinding agreements turn hedging to

the IAEA and NPT's advantage by providing assurances that states can re-proliferate, given a dramatic change in disarmed states' security needs. In any case, stakeholders' objectives should apply the appropriate mechanisms, as previously identified—human, abstract, and physical.

Problem 1 Mechanism Analysis

The primary mechanism is information gathering. That is, the IAEA, NPT states, and nuclear weapons states should have at their disposal the mechanisms necessary for continued information input. Given the uncertain effects of anarchy on the problem, more information that might highlight various states' (especially outlier states') intentions, particularly predictable or designed international developments, is necessary before action can be taken. This, like Problem 1, requires continued human and financial capital.

The information gathered, through inspections, open sources, or third party actors, should be vetted using scientific analysis in a transparent capacity. In other words, robust analysis should be made public. Therefore, two additional nodes are added: Scientific Analysis and Transparency (Transparency also exists within Problem 1, adding interaction along both problems' edges).

This information is subject to intelligence analyses by various states with interest in maintaining the non-proliferation regime or the status quo. Furthermore, the IAEA, conducts acquisition pathway analysis (APA). The APA is a "Structured method used to identity and analyze *all technically plausible paths* for a State to acquire nuclear material suitable for use in a nuclear explosive device"[326] (emphasis mine). This analysis does not factor judgments of intent;

[326] Jill N. Cooley, "State-Level Concept Information" (presentation, Nuclear Nonproliferation, Safeguards, and Security in the 21st Century, Brookhaven National Laboratory, Upton, NY, June 2018), slide 25.

whether or not a state intends to use special nuclear materials for military purposes is outside the APA's scope. The APA factors the state's full nuclear fuel cycle: "existing facilities, quantities and types of nuclear material, knowledge and expertise, past [research and design], capacity to develop or import technology and/or expertise, resources,"[327] etc. The APA, while not explicitly modeled, serves as underlying state-level and international analytical tools and help detect cheating or diversion of special nuclear materials.

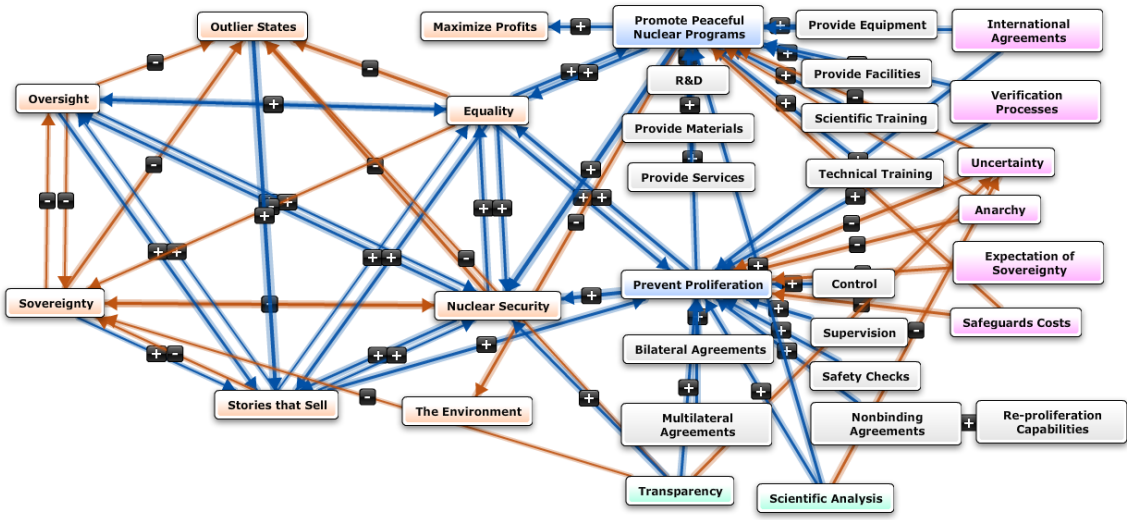
Table 6.15: Problem 2 How Qualitative Link Justification

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Transparency	Sovereignty	-0.25	States have interest in being the least transparent as possible, but the negative relationship is weak because states choose to be transparent by signing multilateral agreements with the IAEA.
Transparency	Nuclear Security	0.75	Transparency increases nuclear security significantly, but not perfectly. The more the IAEA knows about states, the better it can do its job, but states still practice some level of non-transparency.
Transparency	Outlier States	-0.25	This differs from Sovereignty, but the relationship is similarly weak. The transparency norm compels states to cooperate, but Outlier States can choose which programs and to what degree they are transparent.
Transparency	Prevent Proliferation	0.5	Transparency moderately increases proliferation prevention; however, this does not graduate to strong because states can choose how transparent they become without outsiders knowing the difference between varying degrees of transparency.
Transparency	Uncertainty	-0.5	Transparency moderately decreases uncertainty. The more transparent, the less uncertain because knowledge about states' capabilities and intentions are revealed.
Scientific Analysis	Promote Peaceful Nuclear	0.75	Science programs increase states' ability to develop peaceful programs.

[327] Cooley, slide 25.

	Programs		
Scientific Analysis	Prevent Proliferation	0.75	Scientific analyses strongly increase the IAEA's ability to detect cheating or diversion. This includes the APA, special radiation detection devices with isotope identification, and sampling, among others.
Scientific Analysis	Uncertainty	-0.5	Scientific analyses moderately decrease uncertainty by revealing knowledge.

Figure 6.7: Problem 2 FCM How



6.7 Problem 2: When?

Recalling the inequality from the previous chapter $\max\left(\frac{Benefit}{Cost}\right) \geq 1$, this section seeks to assess when and if intervention is necessary. Again, what is the actual cost of intervening, compared to the benefit of intervening? In the system constructed for Problem 2, can the cost of finding a synthesis between actors seeking sovereignty maximizing and actors seeking more nuclear security be justified given the potential payout?

Given high participation among states with the IAEA, it is unlikely that international verification regimes will be replaced with something else in the near term. Furthermore, it is unlikely the system of sovereign states will disappear. Finally, given the structure of the problem and high participation, even among nuclear-armed states, it is feasible that there exists a solution that is mutually beneficial. On the other hand, Outlier States pose an enormous hurdle, and finding synthesis with this group will require a large amount of resources. Therefore, the inequality might not be satisfied.

A final note before simulation: in Problem 1 the timescale was non-defined. In Problem 2 a single iteration represents a calendar year because the IAEA releases its country reports yearly. Therefore, each tick should represent a year, which provides a baseline of understanding. The IAEA releases a report, which triggers the flow of information through the problem. Another way to think about time—which is not included in this model—is as a discrete event simulation. What would happen if a member state withdrew from the IAEA Charter? This would certainly weaken the IAEA's ability to function and influence the problem's outcome.

Table 6.16: Problem 2 Popularity, Activity, and Feasibility[328]

Concept	**Activity**	**Popularity**	**Engagement Priority**	**Change Feasible?**
Equality	4.949747	3.354102	1	N
Nuclear Security	3.872983	6.324555	2	Y
Transparency	3.354102	0	3	Y
Promote Peaceful Nuclear Programs	3.316625	9.721111	4	Y
Oversight	2.738613	2.645751	5	Y
Stories that Sell	2.738613	3.708099	6	N

[328] Recall that popularity is a measure of links going into the concept in descending order, activity is a measure of links coming from a concept in descending order, and measuring the activity rank in ascending order and popularity rank in descending order sets the engagement priority.

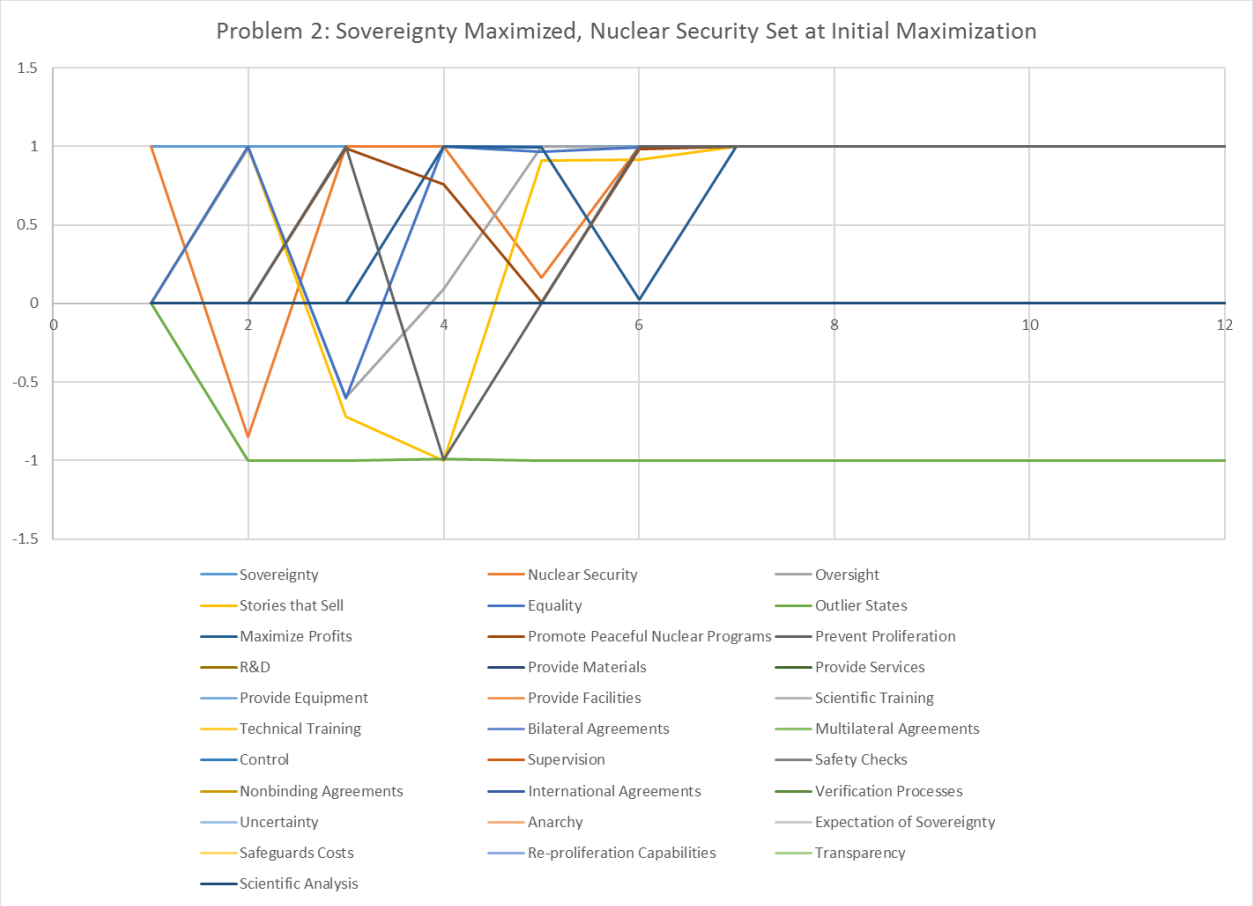
Scientific Analysis	2.44949	0	7	Y
Prevent Proliferation	2.44949	12.32883	8	N
Sovereignty	2.236068	2.738613	9	Y
International Agreements	1.732051	0	10	N
Nonbinding Agreements	1.581139	0	11	Y
Verification Processes	1.581139	0	12	Y
Safeguards Costs	1.414214	0	13	Y
Uncertainty	1.414214	1.414214	14	N
Anarchy	1.224745	0	15	N
Outlier States	1	3.162278	16	N
Safety Checks	0.866025	0	17	Y
Expectation of Sovereignty	0.866025	0	18	N
R&D	0.707107	0	19	Y
Provide Materials	0.707107	0	20	Y
Provide Services	0.707107	0	21	Y
Provide Equipment	0.707107	0	22	Y
Provide Facilities	0.707107	0	23	Y
Scientific Training	0.707107	0	24	Y
Technical Training	0.707107	0	25	Y
Bilateral Agreements	0.707107	0	26	N
Multilateral Agreements	0.707107	0	27	N
Control	0.707107	0	28	Y
Supervision	0.707107	0	29	Y
The Environment	0	0.707107	30	N
Maximize Profits	0	0.866025	31	N
Re-proliferation Capabilities	0	0.866025	32	Y

Running the simulation by pegging sovereignty to 1 and setting an initial increase in nuclear security to its maximum 1, selecting the sigmoid transfer function with λ set at 5, and running the simulation for 50 iterations, it becomes clear that by the tenth year (considering all

else remains constant and no major international changes occur), most stakeholders end up better than before. In this simulation, sovereignty is maximized. No state has lost its ability to function independently of other states or intergovernmental bodies. The initial maximization of nuclear security simulates a significant cooperative event, such as the P5 signing the CSA and maintaining the AP, placing ongoing disarmament programs under the verification purview of the international community. This does not imply that the P5 are dismantling nuclear warheads universally, but rather they accept that nuclear transparency is necessary to beget international nuclear transparency.

Under this regime, nuclear weapons states, NPT states, NGOs, and Production Firms benefit. On the other hand two outcomes call into question this kind of approach to Problem 2. First, uncertainty and anarchy remain unmoved. The constraining forces in international politics have not sufficiently been mitigated. Second, and most importantly, under this universal regime the Outlier States' prestige is minimized to the maximum degree. States like the DPRK and Pakistan no longer receive the respect they get under the status quo. Particularly the DPRK, which is small and insignificant, relative to the major powers, both in terms of military and economic power, might be forgotten about under this outcome. Therefore, it is reasonable to assume that Outlier States would choose to simply ignore any such agreements, which means this is not a feasible solution, given the structure of Problem 2 alone. That stated, the scenario is stable and complicated.

Figure 6.8: Problem 2 Stability Analysis: International Verification



At timestamp 0 Sovereignty is clamped at 1, while Nuclear Security has an initial value of 1. The weight of Sovereignty by timestamp 1, however, shows a significant but short-lived decrease of Nuclear Security, while other stakeholders, except Outlier States, experience tremendous benefit. Outlier States reach a permanent maximum decrease by timestamp 1.

At timestamp 2 Nuclear Security is again increased to the max, while Oversight, Stories that Sell, and Equality decrease. The IAEA's missions to Promote Peaceful Nuclear Programs and Prevent Proliferation experience a maximum increase.

Timestamp 2 indicates that the IAEA and its Board of Governors is acting as a final authority over all things nuclear. NGOs/Activists, the Media, and the NPT States play a lesser

role. For NGOs and Activists, their roles have simply been usurped by the IAEA. For the Media, it becomes difficult to sell stories if the Board of Governors' reports are predictable. NPT States face the largest loss because Equality is strongly undermined by the IAEA's role. However, by timestamp 3 there is a dramatic turn for NGOs/Activists and NPT States.

The aforementioned increase in the IAEA's missions (Promote Peaceful Nuclear Programs and Prevent Proliferation) increase NGOs/Activists' Oversight and NPT States' Equality. While the simulation does not explain why NGOs/Activists receive their reward at timestamp 3, it might be due to having increased access to regimes' nuclear programs through increased transparency. NPT States benefit from increasing their access to nuclear power, which makes them more equal to the rest of the world. The Media, at this timestamp remains diminished. This timestamp also sees a dramatic decrease in the IAEA's mission to Prevent Proliferation. This is likely due to combination of timestamp 2's increase in Promote Peaceful Nuclear Programs and timestamp 1 and 2's decrease in Outlier States. In regards to the latter, we can imagine the DPRK ramping up their nuclear weapons program to deter its destruction by force. Finally, in timestamp 3 Production Firms' profits are maximized, as anarchy under a non-nuclear world require substantial efforts to maintain the BOP with conventional forces.[329]

By timestamp 4 Nuclear Security declines due to movements made by the Outlier States in timestamp 3, as well as the reduction in Prevent Proliferation. On the other hand, NGOs/Activists and NPT States continue to benefit, while the Media dramatically increases its ability to sell stories, due to Outlier States' behavior and failures to Prevent Proliferation in timestamp 3. Prevent Proliferation rebounds slightly by the end of timestamp 4. Profits continue to be maximized, and Promote Peaceful Nuclear Programs still performs marginally.

---

[329] In Chapter 8 I discuss why balancing with conventional forces is not the only way to maintain the BOP without nuclear weapons.

In timestamp 5 the IAEA's Nuclear Security and its mission rebound completely, while NPT States, NGOs/Activists, and the Media continue performing well. Production Firms' profits slow but are still climbing.

By timestamp 6 equilibrium is reached. All stakeholder goals are maximized, with the exception of Outlier States.

The above scenario is a Type IV error. Hypothetically assuming the international community adopts this solution, the Outlier States will simply hold onto their nuclear weapons. And if the P5 disarms, that will significantly shift the balance of power into the hands of states with relatively weak political bodies (with a probable exception of Israel). This might result in civil wars or territorial expansions. Needless to say, however, this hypothetical outcome is beyond the realm of possibilities simply because the solution is extraordinarily improbable without future developments that bring the Outlier States into the mainstream.[330]

Therefore, it is necessary again to remind the reader that the preceding simulation is not a solution to the mess. The simulation is merely to determine system stability and to expose chaotic elements that would require more structuring or restructuring. The obvious Type IV error might disappear when Problems 1 and 2 are merged, but alone it is not a solution.

[330] If this model is accurate, it might therefore be reasonable to conclude that US President George W. Bush's policy that legitimized nuclear trade deals with India simplified this problem by recognizing India's prestige in the international community, thereby mitigating its contrast with the P5 states.

Table 6.17: Problem 2 Stability Analysis End States[331]

Component	**End State**
Sovereignty	1
Nuclear Security	1
Oversight	0.999993
Stories that Sell	0.998894
Equality	1
Outlier States	-1
Maximize Profits	0.998894
Promote Peaceful Nuclear Programs	0.999909
Prevent Proliferation	0.999909
R&D	0
Provide Materials	0
Provide Services	0
Provide Equipment	0
Provide Facilities	0
Scientific Training	0
Technical Training	0
Bilateral Agreements	0
Multilateral Agreements	0
Control	0
Supervision	0
Safety Checks	0
Nonbinding Agreements	0
International Agreements	0
Verification Processes	0
Uncertainty	0
Anarchy	0
Expectation of Sovereignty	0
Safeguards Costs	0
Re-proliferation Capabilities	0
Transparency	0

[331] Recall that a change of +1 means a maximum increase, -1 means a maximum decrease, and 0 means the status quo.

6.8 Summary

This chapter uses fuzzy cognitive mapping to confront the challenges preventing synthesis between cooperation and sovereignty. It first identifies stakeholders and their goals and how those goals interact with other stakeholder goals. It then abstracts the IAEA's goal, as the prioritized stakeholder and finds the IAEA's ultimate goal is nuclear security. Applying the boundaries, constraints, and mechanisms to the problem, this model then determines interaction is possible and that the system is stable.

CHAPTER 7

THE MESS

7.1 The Messy Nuclear Landscape

The "messy" nuclear landscape contains several familiar aspects of international being—disagreements, varying degrees of power, costs, benefits, and problems with solutions thus far beyond the reach of practitioners—but at the center of the "messy" nuclear landscape is something wholly unique in international politics. The entire "mess" has built itself, through ever-evolving layers of complexity, around a bizarre development of technology not found elsewhere in the world (outside of science fiction novels and movies). That is, there exists a technology capable of curing diseases, sterilizing biological contaminants, and providing power to the entire world population at a cost far below the average, but this same technology can also cause the extinction of most earthly life.

Compounding this already complex problem is the unholy realization that in dyadic and equal relationships, simply possessing nuclear weapons simplifies the world around us. If war is not an option, other, less-malignant bilateral behavior is less unlikely.

Under the veil of ignorance,[332] one might be forgiven for choosing a world without nuclear technologies. They might rationalize that the costs of nuclear war are so high that the costs of war are relatively acceptable in a world without MAD and the risk of escalation. Indeed, Chapter 2 attempts to make this connection. They might further rationalize, therefore, that non-proliferation is a norm that must be upheld at any cost. Under these caveats, a lucky chooser might choose a world where every state—or at least almost every state—has nuclear weapons

[332] John Rawls, *A Theory of Justice* (Cambridge, Mass.: Belknap Press of Harvard University Press, 1971).

and a second strike capability, while counting on the threat of guaranteed retaliation and certain death to maintain universal good nuclear stewardship.

The reality of the present system of states under anarchy is that practitioners do not get to choose the world they inherit, but they can make changes to the way things are. And given the choice between doing something for the good of humanity or not if given the opportunity, most practitioners will choose to go the moral route—on a long enough timeline.[333] Some of these changes might be radical, like the banning of slavery or the reunification of Germany, and others might happen sluggishly, so slowly that society never notice its passing. American pistol duels come to mind, where, although outlawed by many states by the 19th century, they continued occurring into the 20th century. No one noticed the day pistol duels met a timely demise, but, given today's standards, it is an unthinkable way to settle scores.

The point is that significant changes occur, despite seemingly structural forces maintaining the status quo, and often, as Müller points out, these changes occur through a social process.[334] It would be foolish to assert without evidence that nuclear weapons programs are beyond the reach of change. And whether they inhabit the world out of necessity or habit, their existence poses fair questions. If these questions were truly unsolvable, then no one would be having these discussions. But the reality is that dismantling a nuclear weapon is easy. Finding a world where dismantling all nuclear weapons is not unthinkable; achieving it is merely sufficiently difficult.

In the previous two chapters, two problems barred the path to global zero. First, nuclear weapon states are resistant to giving up nuclear weapons, despite agreements to disarm, according to Article VI of the NPT. This resistance comes despite significant international

---

[333] Pinker, see esp. chap. 1.
[334] Müller, 69-70.

pressure to disarm. International pressure is a moral imperative, even if disguised as issues of equality or cost. Second, the role that the IAEA plays in ensuring states are using their nuclear programs safely and refraining from weaponizing fissile materials is contrasted by an unfortunate effect of sovereignty. That is, despite signatures on international agreements, no state can be compelled into compliance without ultimately going to war. States have vested interest in protecting certain information. The largest thing working towards synthesizing this problem is the fact that the majority of the world believes that IAEA cooperation stabilizes the world. But this is wholly offset by the fact that it only takes one nuclear-armed state that wishes to disregard the rules to undermine the whole thing—and there are several of them.

These two problems do not exist independent from one another. They share measurable levels of overlap, and solving one without regard to the other runs the risk of committing the Type IV error, where the disregarded problem is exasperated. Therefore, synthesis and solution is not problem-specific. It requires synthesis on two fronts, while special attention must be given to the interactions between the problems. Therefore, in order to analyze the mess—both problems at once—a meta-perspective must be developed. This is shown in Figure 7.1.

The Nuclear "Mess"

Figure 7.1, or the "mess," appears to be too complicated to understand, but, if one followed along with the building of Problems 1 and 2 in the previous chapters, one can see that it looks somewhat familiar. Problem 1 inhabits the top fifty percent of the mess. Problem 2 sits below (nodes that exist in both problems only appear in the top part of the mess). Between them are various points of overlap. As one can see, there is a significant similarity between the two. The media has identical goals between both problems, meaning it is more active than most

stakeholders. This biases the media in measuring engagement priority. One could take note of this and run a simulation where the media's goal is permanently maximized, but this is an unfeasible change. In order to make the media the happiest, unfortunate events would need to occur on a regular basis.

Figure 7.1: The Mess

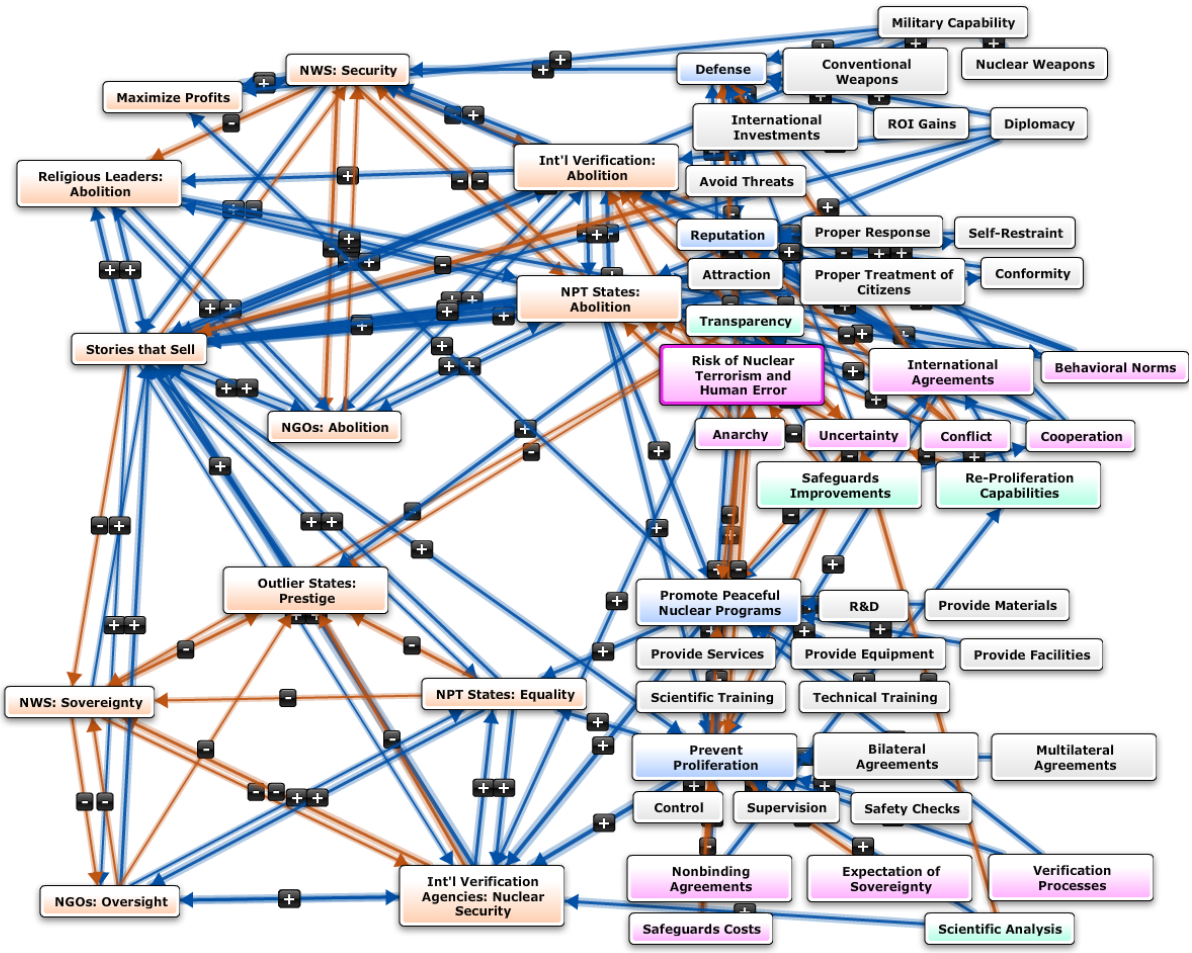
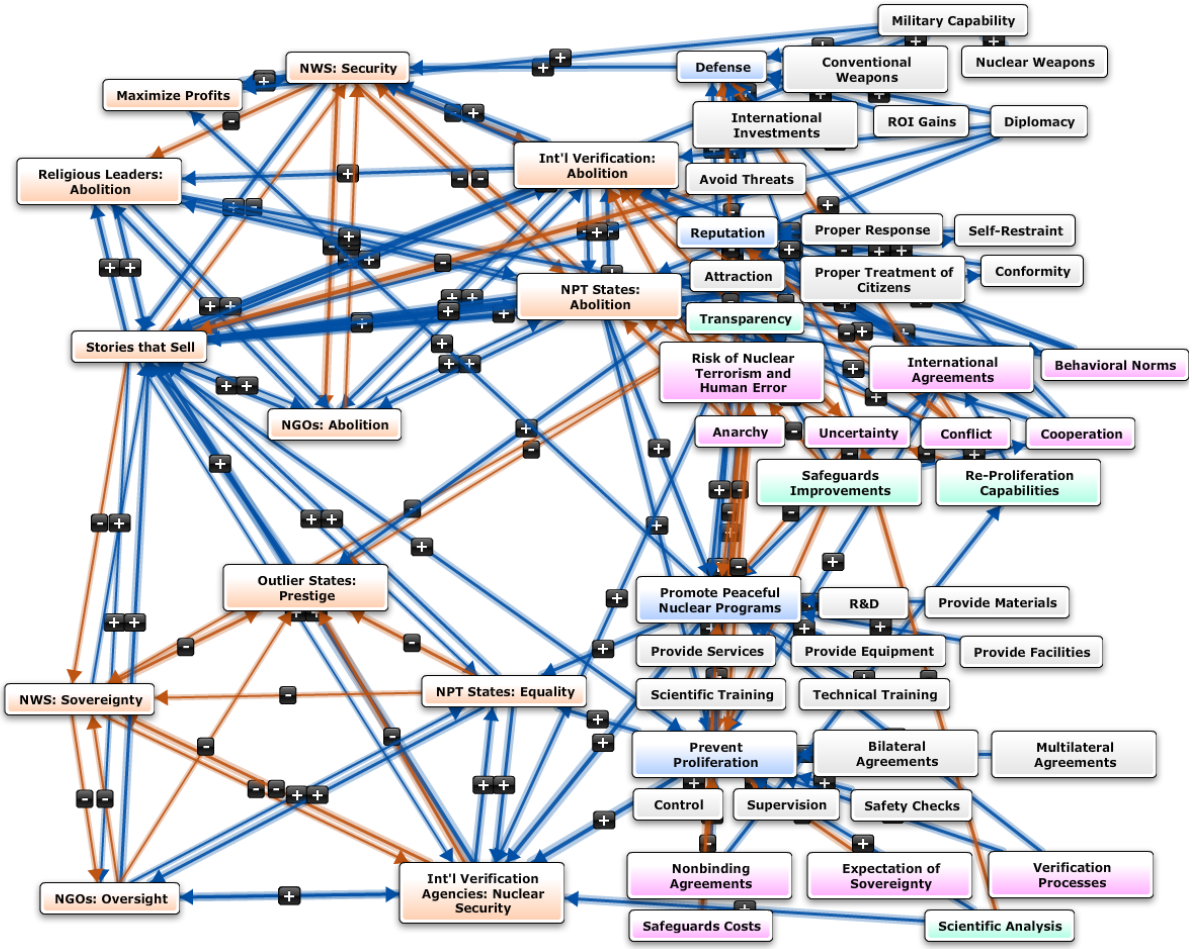


Figure 7.2: Updated Mess



What also becomes apparent is that some nodal relationships exist but are not represented in the mess. This is due to insufficient information while modeling problems individually. Therefore, careful consideration must be given to potential hidden movements, and these links must be identified. In other words, the "mess" requires restructuring. For example, there is a feedback loop between the risk of nuclear terrorism and human error with the prevention of proliferation. That is, the risk of nuclear terrorism or human error increases resources devoted to proliferation prevention. Additionally, preventing proliferation decreases the threat of nuclear

terror or human error. These points of overlap and mess-level refinement are identified in Table 7.1.

Table 7.1: Updates to Mess Link Justifications

Sender Component	**Receiver Component**	**Link**	**Reasoning**
Risk of Nuclear Terrorism and Human Error	Promote Peaceful Nuclear Programs	0.5	The risk of nuclear terror or human error increases attention paid and resources allocated to the promotion of peaceful nuclear programs.
Promote Peaceful Nuclear Programs	Risk of Nuclear Terrorism and Human Error	-0.75	The promotion of peaceful nuclear programs reduces the risk of nuclear terror or human error by placing materials under safeguards.
Attraction	Outlier States: Prestige	0.75	Soft power strongly increases prestige, but it is not a perfect relationship because it is not within the practitioner's control.

Recalling Hester and Adams' TAO approach, further modeling often requires restructuring. With that end in mind, the "nuclear weapons" node can now be modeled more centrally. Therefore, moving forward nuclear weapons' involvement in the model is reconsidered to determine how they interact with other components, and how the problems will change if nuclear weapons are removed from the system. If removing nuclear weapons has no ill effect on the problems, then it would be reasonable to conclude that disarmament is feasible in the long term and would not cause a Type IV error.

As mentioned previously, Richardson's arms race model is incapable of being reworked back to zero, particularly because 1) states cannot possess less than one weapon if the other side possesses more than zero weapons, and 2) the cost of being the second-to-last state to disarm is high. Diminishing weapons redundant beyond deterrence is simple when the stockpile is large.

The INF treaty can be viewed as simple posturing when both the US and the Soviet Union knew that total abolition was not within the set of possible end states. Dismantling 1,000 weapons is simple if one has 10,000 in deployment. Dismantling 100 is significantly more difficult if one has 1,000 warheads. The cost rises exponentially as each end line is passed. Terminus appears endlessly beyond reach.

There is future work in this field, to be certain. The next mathematician might discover a psychological delta that can compel reductions from ten redundancies to zero. Or perhaps there is natural random variation, or the trembling of an actor's hand, that enacts the abolition play when least expected. But that is not the point of this research.

This research seeks to explore disarmament-ready end states. To find synthesis between realists, on the one hand, and abolitionist moral crusaders, on the other, is already a heavy burden to carry, and it is the narrow scope of this research. Modeling the political mine field, where nuclear options shrink with each step, is not within this research's scope. Therefore, to save needless debate about what disarmament would look like, the best course of action is to examine pre- and post-disarmament scenarios. Is a disarmed world preferable to a world where some actors have nuclear weapons? If the scope of this research is not satisfying, Perkovich and Acton, among others, have already performed some of the legwork to analyze what happens when nuclear stockpiles diminish.[335] For the sake of completion, a brief summary is necessary.

Perkovich and Acton argue the problem with reducing redundant weapons is really a trust problem. How much verification is necessary to displace distrust? This pits technical considerations against political concerns, with significant overlap between the two. They call

[335] Perkovich and Acton, see esp. chap. 2.

these "political-technical" challenges.[336] On the one hand, nuclear weapons states would require significant verification capability to allay concerns. They do not argue that perfect verification is necessary,[337] but rather, there needs to be a universally acceptable threshold for confidence. On the other hand, the risk of breakout nuclear weapons programs in a disarmed world requires the political will to enforce maintenance of a universal nonproliferation regime.[338] This necessitates verification of declared systems, detection of diverted or clandestinely hidden warheads, and the utilization of intelligence agencies to help ensure compliance.

Verifying declared warheads, components, and facilities takes on processes similar to existing IAEA inspections—random sampling of containers holding warheads queued for destruction, tamper-resistant seals, continued monitoring of destruction facilities, comparisons of radioactive spectrums, among others.[339] Accounting for potential hidden weapons requires accurate auditing with statistical analysis to reconcile past production with current holdings (which, they point out, would already be being undertaken in the verification of declared materials), nuclear archeology to reconstruct plutonium production levels in graphite-moderated reactors, and challenge inspections when the verification body has legitimate concerns that a state is conducting illicit nuclear activities, while the inspected state retains the right to access management.[340] This also resembles IAEA complementary accesses under the AP. Intelligence agencies are useful compliance verification tools because, as Richard L. Garwin points out, states engaged in clandestine nuclear activities must engage in certain telltale behaviors, such as

[336] Perkovich and Acton, 107.
[337] Perkovich and Acton, 42.
[338] Perkovich and Acton, 107.
[339] Perkovich and Acton, 46-52.
[340] Perkovich and Acton, 52-54, 57.

informing certain personnel about clandestine nuclear weapons programs in confidence, building certain security and surveillance facilities, and transporting components in the open.[341]

Once states can overcome these challenges with a high level of confidence, political will to offer transparency in good faith becomes simpler. Perkovich and Acton use the South Africa model to show how strong verification tools from the international community mixed with high levels of state transparency can increase international confidence that a state has completely disarmed and not retained significant quantities of nuclear materials.[342] In other words, getting to zero is not unthinkable; one state has already forged the path.[343]

Michael E. O'Hanlon also explores the means by which redundant nuclear stockpiles can be reduced to zero. His more conservative approach mimics Perkovich and Acton's conclusion (identified in Problem 1[344]) that the solution is not to permanently abolish states' rights to nuclear proliferation, but rather, to dismantle nuclear weapons.[345] In other words, O'Hanlon makes clear that policymakers should strive towards a world where nuclear weapons, their components, and ready-to-use fissile materials do not exist, while keeping in mind that no

---

[341] Richard L. Garwin, "Technologies and procedures for verifying warhead status and disarmament," in *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions*, ed. Nicholas Zarimpas (Solna, Sweden: Oxford University Press, 2003), 152.
[342] Perkovich and Acton, 61-62.
[343] On the other hand, a reasonable argument is the reduction of serious security concerns made South Africa's disarmament possible—for example, the collapse of the Soviet Union led to significant threat reductions from Marxist revolutionaries fighting along the Northern border; the ceasefire in the South African Border War, which granted Namibia's independence and created a buffer between South Africa and Angola; as well as the transition from apartheid to majority rule, which significantly reduced South Africa's internal threat. Once South Africa had significant reason to feel secure, it was possible to disarm. This is coupled with South Africa's nuclear- and apartheid-induced isolation, which curtailed South Africa's access to international commerce. South Africa, feeling secure, merely used disarmament as a means to re-enter the global economy. This fits with the means ends network in Problem 1.
[344] Perkovich and Acton, 102.
[345] O'Hanlon, Kindle location 937.

international accord, particularly one seeking to ban an entire class of weapons, should or can be permanently binding. His reasoning follows Graham Allison's. That is, states might need to periodically reconstitute nuclear weapons to contain threats and provide credible deterrence. Why is deterrence necessary? In a world where the rising power often militarily challenges the declining power, "[States] must think the unthinkable to credibly deter potential adversaries…"[346] That is, as will be discussed in the next chapter, periodic re-armament might prevent tense situations from spiraling out of control. Threats to proliferate or threats of proliferation signal possible willingness to use nuclear weapons, preserving deterrence. O'Hanlon is skeptical that any country would agree to dismantle their bombs without a significant portion of a future treaty discussing how the treaty can be temporarily suspended under certain conditions.[347] O'Hanlon would probably call for language similar to, but more robust than, the NPT's Article X, which allows for withdraw if remaining party to the treaty severely jeopardizes states' interests.

Under O'Hanlon's model, disarmament requires three steps. First, international disputes, such as questions over Kashmir, sea beds off the coast of China and Japan, and security alliances between the US and former Soviet states or satellites must be resolved. O'Hanlon does not call for a utopian end state before negotiations can begin, but rather that the list of ongoing international disputes be limited. Second, once many of these (and any intervening) issues are resolved, an accord can be drafted that requires all nuclear weapons and weapons-grade fissile materials be destroyed under IAEA-like mechanisms, and states are provided re-proliferation

[346] Graham Allison, "The Thucydides Trap," *Foreign Policy*, June 9, 2017. https://foreignpolicy.com/2017/06/09/the-thucydides-trap/.
[347] O'Hanlon, Kindle location 957.

capabilities.[348] O'Hanlon furthermore argues re-proliferation capabilities must be in short order. Perkovich and Acton call this "virtual nuclear arsenals" and peg the re-proliferation capability in weeks, or possible months.[349]

In neither of these models do the authors tackle the large question—how do states' calculi change as warhead numbers decline? O'Hanlon avoids this problem and proposes a reduction in US-Russian forces to 1,000 while preserving second-strike, land, sea, and air capability[350] and stops there (for now). The answer is not simple, and whatever the answer is must violate the arms race model. To reiterate a previous objective: This model does not answer that question. Rather, it seeks to determine what a post-disarmament world would look like, given that certain changes are made.

Therefore, how do nuclear weapons (and conventional weapons) more broadly and directly impact the mess' components?[351] Moving nuclear and conventional weapons from tertiary components in the model to driving forces requires some contextual understanding.

Table 7.2: Updates to Mess with Nuclear/Conventional Weapons Link Justifications

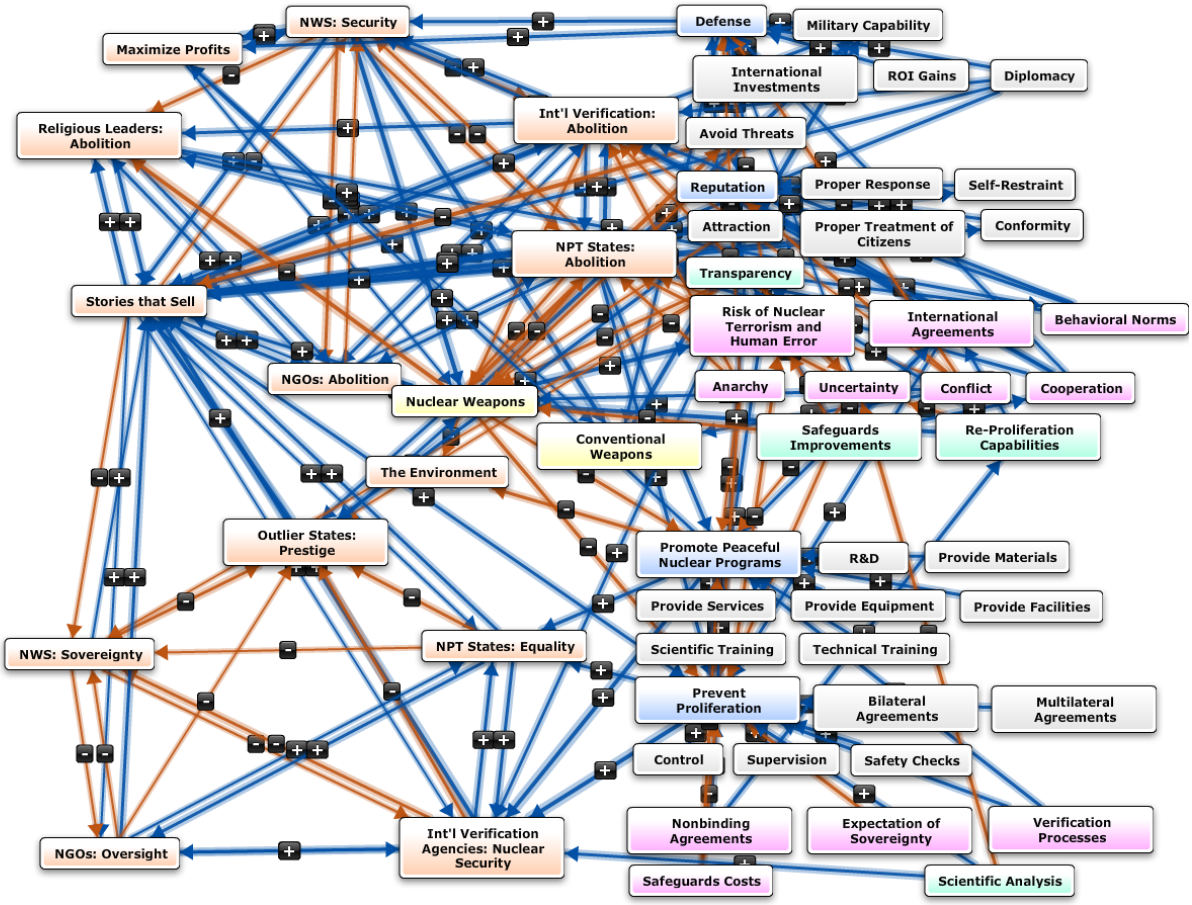
Sender Component	**Receiver Component**	**Link**	**Reasoning**
Nuclear Weapons	NGOs: Abolition	-1	Non-state actors have no control over whether or not a state possesses nuclear weapons.
Nuclear Weapons	Stories that Sell	0.5	The media can sell stories about proliferation, but they can also sell stories about non-proliferation and disarmament.
Nuclear Weapons	NPT States: Abolition	-0.75	Ultimately, NPT states cannot compel disarmament, but they have some measurable

[348] O'Hanlon, Kindle locations 1036, 1040, and 1080.
[349] Perkovich and Acton, 101, 102, and 104.
[350] O'Hanlon, Kindle location 1261.
[351] Prior to this point in the model, the "Nuclear Weapons" and "Conventional Weapons" nodes fed the problems but were not affected by the problems. At this point, I examine both how they affect the "mess" and are affected by the "mess."

			power remaining.
Nuclear Weapons	Religious Leaders: Abolition	-1	Non-state actors have no control over whether or not a state possesses nuclear weapons.
Nuclear Weapons	Military Capability	1	Nuclear weapons very strongly increase military capability.
Nuclear Weapons	Avoid Threats	-1	Proliferating or possessing nuclear weapons can be very threatening.
Nuclear Weapons	Risk of Nuclear Terrorism and Human Error	1	The existence of nuclear weapons defines this risk.
Nuclear Weapons	Outlier States: Prestige	0.75	Outlier States use nuclear weapons to bolster their prestige.
Nuclear Weapons	Promote Peaceful Nuclear Programs	-0.75	This relationship is strong because peaceful nuclear programs can be used to proliferate, especially if the state withdraws from the NPT.
Nuclear Weapons	Prevent Proliferation	-0.75	If one state has nuclear weapons, it reduces the success of nonproliferation. This relationship is crucial because under the status quo, nuclear weapons exist. This relationship is therefore by design.
NWS: Security	Nuclear Weapons	1	Nuclear weapons states decision to proliferate defines the existence of nuclear weapons.
Maximize Profits	Nuclear Weapons	0.25	This relationship exists because Production Firms can submit designs for new weapons, but it is weak because the ultimate authority comes from NWS.
Int'l Verification: Abolition	Nuclear Weapons	-0.75	The IAEA plays a large role in the prevention of nuclear weapon proliferation; however, their role in convincing NWS to disarm is less pronounced
NPT States: Abolition	Nuclear Weapons	-0.5	NPT States define abstention from nuclear weapon possession; however, this relationship is moderate because the NPT State can withdraw and proliferate if it chooses.
Avoid Threats	Nuclear Weapons	-0.5	Avoiding threats means abstaining from proliferation.
Transparency	Nuclear Weapons	-0.5	Being transparent shines lights on nuclear weapons programs.
Attraction	Nuclear Weapons	-0.25	Soft power through non-nuclear weapons states makes nuclear weapons less attractive.
Conflict	Nuclear Weapons	0.5	Conflict increases the likelihood that a state will proliferate, but proliferation is rare, so the link is moderate for now.

Re-Proliferation Capabilities	Nuclear Weapons	1	Re-Proliferation Capabilities means nuclear weapons are possible by definition.
Safeguards Improvements	Nuclear Weapons	-0.75	Improvements to safeguards significantly lower possible proliferations.
Outlier States: Prestige	Nuclear Weapons	0.5	This is moderate because prestige can be obtained through other means.
NWS: Security	Conventional Weapons	1	This link is strong because nuclear weapons states tend to spend significantly on their conventional capabilities.
Maximize Profits	Conventional Weapons	0.25	This relationship exists because Production Firms can submit designs for new weapons, but it is weak because the ultimate authority comes from the state.
Defense	Conventional Weapons	0.5	Defense relies partly on conventional weapons.
Conflict	Conventional Weapons	0.75	Increased conflict is going to increase the demand for conventional weapons greatly.

Figure 7.3: The Mess and Nuclear Weapons



7.3 Modeling Nuclear Disarmament

Figure 7.3 shows the updated FCM with nuclear and conventional weapons inhabiting space in the center of the model and highlighted in yellow. The figure also shows directional relationships. Of particular note is that nuclear weapons do not directly influence nuclear weapons states' security, due to its preexisting influence on military capability, which influences defense, and which in turn influences security. This indirect relationship was previously identified in Problem 1 when the fundamental objectives hierarchy and means ends network

updated nuclear weapons states' objective from maintaining nuclear weapons to maximizing its security.

Additionally, the nuclear weapons node, as illustrated in Figure 7.3, is now the dominant node, with the highest engagement priority. It also becomes apparent that the "nuclear weapons" node interacts much more with Problem 1 than Problem 2. In other words, nuclear weapons are more likely to influence the security problem than the cooperation problem. To determine how nuclear weapons affect the outcome of the mess, emphasis should be placed on components from Problem 2.

Table 7.3: Mess Popularity, Activity, and Feasibility[352]

Concept	Activity	Popularity	Engagement Priority	Feasible Change?
Nuclear Weapons	9.219544457	8.455767263	1	Y
Stories that Sell	8.774964387	11.61895004	2	N
NWS: Security	6.633249581	4.769696007	3	Y
NPT States: Abolition	6.164414003	9.367496998	4	Y
Transparency	5.123475383	1.58113883	5	Y
Safeguards Improvements	4.898979486	0	6	Y
Int'l Verification: Abolition	4.74341649	8.124038405	7	Y
International Agreements	4.330127019	1.414213562	8	Y
Int'l	4.18330	6.3245553	9	Y

[352] Recall that popularity is a measure of links going into the concept in descending order, activity is a measure of links coming from a concept in descending order, and measuring the activity rank in ascending order and popularity rank in descending order sets the engagement priority.

Verification Agencies: Nuclear Security	0133	2		
Uncertainty	3.535533906	3	10	N
NPT States: Equality	3.535533906	3.354101966	11	N
Anarchy	3.162277660	0	12	N
Conflict	3.162277660	0	13	N
Cooperation	3.162277660	0.707106781	14	Y
Attraction	3.162277660	0.866025404	15	N
Re-Proliferation Capabilities	3.162277660	0.866025404	16	Y
NGOs: Abolition	3.162277660	4.74341649	17	Y
Prevent Proliferation	3.162277660	13.91042774	18	Y
Diplomacy	3	0	19	Y
Military Capability	2.738612788	2	20	Y
NGOs: Oversight	2.738612788	2.645751311	21	Y
Religious Leaders: Abolition	2.645751311	4.74341649	22	Y
Promote Peaceful Nuclear Programs	2.598076211	10.60660172	23	Y
Scientific Analysis	2.449489743	0	24	Y
Avoid Threats	2.449489743	1	25	Y
NWS: Sovereignty	2.236067977	2.738612788	26	N
Behavioral Norms	2.121320344	0.707106781	27	N
Outlier States: Prestige	1.732050808	4.949747468	28	Y
Nonbinding	1.58113	0	29	Y

Agreements	883			
Verification Processes	1.58113 883	0	30	Y
Defense	1.58113 883	7.9529868 6	31	Y
Reputation	1.58113 883	8.4557672 63	32	N
Safeguards Costs	1.41421 3562	0	33	Y
Risk of Nuclear Terrorism and Human Error	1.22474 4871	2.5980762 11	34	N
Conventional Weapons	1	1	35	Y
Maximize Profits	1	2.7386127 88	36	N
Proper Response	0.86602 5404	0	37	Y
Safety Checks	0.86602 5404	0	38	Y
Expectation of Sovereignty	0.86602 5404	0	39	N
ROI Gains	0.70710 6781	0	40	Y
International Investments	0.70710 6781	0	41	Y
R&D	0.70710 6781	0	42	Y
Provide Materials	0.70710 6781	0	43	Y
Provide Services	0.70710 6781	0	44	Y
Provide Equipment	0.70710 6781	0	45	Y
Provide Facilities	0.70710 6781	0	46	Y
Scientific Training	0.70710 6781	0	47	Y
Technical Training	0.70710 6781	0	48	Y
Bilateral Agreements	0.70710 6781	0	49	Y
Multilateral Agreements	0.70710 6781	0	50	Y
Control	0.70710	0	51	Y

	6781			
Supervision	0.70710 6781	0	52	Y
Self-Restraint	0.70710 6781	0.7071067 81	53	Y
Conformity	0.70710 6781	0.7071067 81	54	Y
Proper Treatment of Citizens	0.5	0.7071067 81	55	Y

There are several feasible concepts that can be changed. However, there are certain constraints on what will be tested. First, remembering that the new world must resemble the old world in terms of sovereignty and that realist assumptions about world order still apply, scenarios will not be run that give NGOs (for example) a preponderance of power, despite NGOs being relatively high on the engagement priority. Instead, non-state actor groups and intergovernmental organizations will be assessed more than changed. For the purpose of handling the mess, the state is the referent object, particularly the nuclear weapon state. If the state does not benefit then the state is not expected to participate in the discussion. Therefore, several scenarios will be run that focus on the state. Note: To save space, the End State reports will only include components that exhibit change, with the exception of sovereignty, where applicable. Concepts that remain at zero will be excluded from discussion unless there is reason to include them.

Table 7.4: Mess Scenario Exploration

	Summary	Performance
Scenario 1	• NPT states Abolition set initially to 1, simulating universal acceptance of NPT • Nuclear weapons node clamped to -1 to simulate disarmament	Stable and Complicated. NWS' goals in both problems greatly reduced. Several key stakeholders are unhappy. Multiple error types possible.
Scenario 2	• NPT states Abolition set initially to 1 • Sovereignty clamped to 0 (compelling no change in sovereignty) • Nuclear weapons node is clamped to -1	Stable and Complicated. Multiple key stakeholders suffer greatly diminished goals. IAEA and NPT states are happy Potential Type IV error: NWS and Outlier States simply refuse to disarm, opting instead to continue to balance. Furthermore, this diminishes trust in future treaties
Scenario 3	• Security is maximized by clamping security to 1 • Nuclear weapons node is clamped to -1	Stable and Complicated. This solves Problem 1, but maintenance requires NWS to give up substantial amounts of sovereignty Potential Type IV error: This strongly suggests future security dilemmas and potential militarized international disputes
Scenario 4	• Sovereignty is clamped to 0 • International verification has an initial setting of 1 • Nuclear weapons node is clamped to -1	Periodic and Complex. There is no end state that reaches equilibrium This requires further interaction with the problem
Scenario 5	• Sovereignty is clamped to 0 • Cooperation initially set to 1, denoting the successful signing of a disarmament treaty • Outlier States' prestige is clamped to 0.25 • Nuclear weapons node is clamped to -1	Stable and Complicated. Solves both problems. Potential Type IV errors: Neither anarchy nor uncertainty are reduced. Therefore, if disarmed under this framework, potential clandestine defection can occur, shifting the BOP. Additionally, this might signal to less-powerful states that proliferating and then agreeing to disarmament can be rewarding. Finally, a "security period of vulnerability" is identified.

In Scenario 1 the NPT states are prioritized. Their goal to maximize total adherence to NPT Article VI means the nuclear weapons states take their Article VI responsibility seriously enough that nuclear weapons states can disarm. There is no expectation that nuclear weapons states will enthusiastically accept this scenario's outcome; however, it is reasonable to test if only to exclude this solution from future negotiations. This scenario is sparse and should exemplify the need to include solutions that benefit across stakeholder types.

In Scenario 2, therefore, NPT States are given an initial setting of maximized adherence to the abolition provision in the NPT's Article VI. In other words, the nuclear weapons states have sat down and agreed to take significant steps towards abolition; however, this agreement is not yet legally binding. They have agreed merely to start working towards their commitments—gradual disarmament that is subject to the whims of international order or disorder. In order to satisfy nuclear weapons states that their sovereign goals outside of nuclear policy are taken seriously, the nuclear weapons states' sovereignty node is clamped to its maximum state, which simulates an agreement that does not affect its sovereign abilities outside of the agreement. Finally, the nuclear weapons node is clamped to its maximum decrease, simulating the elimination of nuclear weapons. This scenario is likely to diminish nuclear weapons states' goal for maximized security, but the scenario requires exploration to see if there exists a path towards abolition that naturally increases security.

In Scenario 3 focus shifts to security. What happens if moving forward with a nuclear abolition accord, nuclear weapons states focused all of their attention on maximizing their security? This would be somehow compelled disarmament in a realist world. No other stakeholders matter. That is, security is clamped to its maximum increase and nuclear weapons

are clamped to their maximum decrease. This scenario is included because it is hypothesized that it will solve the nuclear weapons states' first problem, but cause a Type IV error regarding their second problem—in this contradictory world, the nuclear weapons states would have to yield to the IAEA through treaty rather than through Müller's social evolution.

In Scenario 4 sovereignty is again maintained at the present-day status quo. No change will occur between timestamps. The IAEA's ability to verify compliance is initially maximized but subsequently left up to nature (the sigmoid transfer function). Finally, nuclear weapons are clamped to their maximum decrease. It is hypothesized that without constant IAEA supervision, states, particularly the nuclear weapons states and the Outlier States will constantly vie for superiority against the IAEA's continued need to manage nuclear affairs. In other words, the nuclear-armed states will likely disallow the IAEA from empowering itself beyond the power granted it by member states. It is unlikely this solution will solve the problem but is included because it will demonstrate present day assumptions about disarmament. Compelled disarmament, regardless of security needs will likely result in fierce debate between states and international organizations, diminishing the role international organizations play in future debates, particularly debates over nuclear weapons.

Finally, in Scenario 5 the nuclear weapons states' need for continued guarantees of sovereignty beyond a successful global disarmament accord is maintained. Rather than empowering the IAEA directly by setting it initially at its maximum, empowerment is shifted to the states through the signing of a treaty, including that nuclear weapons states accept the CSA in addition to their established acceptance of the AP. This is simulated by initially setting the "cooperation" node to its maximum value. In other words, the *state* is choosing to cooperate on a single item for a specific period of time (during the signing and ratification processes only), and

they are not agreeing to cooperate on any matter beyond the articles in a global disarmament treaty. As will be discussed later, this is merely symbolic and has no cause and effect relation with a successfully implemented (rather than merely signed) disarmament treaty. This is because states can sign the treaty, ratify the treaty, and make public statements about the treaty's communal significance, but secretly hide nuclear hedging activities or even entire weapons unknown to inspectors. In other words, the signing of the treaty is meaningless outside of its cultural (in the nuclear context) meaning. Here, Outlier States too must be brought in. this scenario empowers the Outlier States' prestige to a minor degree. It does not seek to empower the Outlier State to a maximum degree. That is, Pakistan and the DPRK are not empowered by being granted veto power at the UN Security Council, but their needs to be recognized as 1) a nuclear power and 2) an important actor in the international movement towards global zero. The Outlier State here is brought into the NSG, relieved of any ongoing nuclear (or other relevant) sanctions, and perhaps, as will be addressed later, temporarily forgiven for any human rights violations. Some progress has already been accomplished here. Israel, for example, has not suffered nuclear sanctions, despite its weapons program. India's access to the NSG has been greatly increased, despite provisions in the NPT that likely prohibits India's access. In other words, the international community might need to apply responses to non-NPT nuclear powers consistently, rather than calling some "rogue nations" and others Western allies. Further, it will likely require this consistent reaction to be more like the response towards Israel or India, rather than towards the DPRK. This is further explicated in a footnote below. Finally, as in Scenarios 1 – 5, the nuclear weapons node is clamped to a maximum decrease, simulating global disarmament. This scenario will likely "solve" the nuclear weapons problems as defined in the two previous chapters, but it will likely not resolve the natural problems of uncertainty and

anarchy. Given the parameters of the "mess," however, this might be the best path forward thus far.

Running the simulations with the sigmoid transfer function for 100 timestamps (again, to ensure the scenarios are either stable or periodic), in the first three scenarios multiple error types are possible, especially the Type IV error this model seeks to avoid. In Scenario 4, there is no end state that reaches equilibrium following 100 timestamps. Finally, Scenario 5 reaches a stable equilibrium in which all stakeholders are satisfied. On the other hand, a "security period of vulnerability" exists (discussed below) that threatens to undermine a successful and lasting disarmament treaty. Scenario 5 requires the understanding that nuclear weapons states will not be burdened beyond the disarmament treaty. IAEA inspectors are not given free reign to investigate any suspected wrongdoing. Additionally, it requires understanding that the Outlier States must be brought into the fold.[353]

7.4 Preliminary Results

Table 7.5: Mess Scenario 1 NPT Signing End States

Concept	End State
NWS: Security	-0.99999995
Maximize Profits	-0.99990920
Int'l Verification: Abolition	0.99999995
NGOs: Abolition	1
Stories that Sell	-0.98648523

[353] Significant effort has already been made to include Outlier States in international nuclear policies. US Presidents George W. Bush and Barack Obama worked to include India in international nuclear trade deals, despite India being on the Nuclear Suppliers Group control list since 1974, preventing its inclusion in trade regimes. US President Donald Trump and ROK President Moon Jae In furthermore undid a decades old unofficial international policy to not recognize the DPRK regime as legitimate. This modeling seeks to capture that level of Outlier State inclusion without giving into Outlier State demands.

NPT States: Abolition	1
Religious Leaders: Abolition	1
Reputation	-0.99999999
Defense	-0.99889494
Military Capability	-0.99999999
Nuclear Weapons	-1
Conventional Weapons	-0.99990920
Avoid Threats	0.999909204
Self-Restraint	-0.98568521
Proper Treatment of Citizens	-0.98568521
Conformity	-0.98568521
Attraction	-0.99877657
Risk of Nuclear Terrorism and Human Error	-0.99999875
Behavioral Norms	0.986614298
NWS: Sovereignty	-0.99893113
Int'l Verification Agencies: Nuclear Security	1
NGOs: Oversight	0.999992775
NPT States: Equality	0.999999901
Outlier States: Prestige	-1
Promote Peaceful Nuclear Programs	0.999999898
Prevent Proliferation	0.857491435

Table 7.6: Mess Scenario 2 NPT Signing and Recognition of Sovereignty End States

Concept	**End State**
NWS: Security	-0.99999996
Maximize Profits	-0.99990920
Int'l Verification: Abolition	0.999999975
NGOs: Abolition	1
Stories that Sell	-0.84571771
NPT States: Abolition	1
Religious Leaders: Abolition	1
Reputation	-0.99999999

Defense	-0.99889494
Military Capability	-0.99999999
Nuclear Weapons	-1
Conventional Weapons	-0.99990920
Avoid Threats	0.999909204
Self-Restraint	-0.97127275
Proper Treatment of Citizens	-0.97127275
Conformity	-0.97127275
Attraction	-0.99648773
Risk of Nuclear Terrorism and Human Error	-0.99999911
Behavioral Norms	0.986614298
NWS: Sovereignty	0
Int'l Verification Agencies: Nuclear Security	1
NGOs: Oversight	0.999938261
NPT States: Equality	0.999999951
Outlier States: Prestige	-1
Promote Peaceful Nuclear Programs	0.999999928
Prevent Proliferation	0.926870161

Table 7.7: Security Maximized

Component	**End State**
NWS: Security	1
Maximize Profits	0.99999995
Int'l Verification: Abolition	0.999999946
NGOs: Abolition	1
Stories that Sell	1
NPT States: Abolition	1
Religious Leaders: Abolition	1
Reputation	1
Defense	0.999992509
Military Capability	-0.00045397
Nuclear Weapons	-1
Conventional Weapons	0.999909204
Avoid Threats	0.999909204
Self-Restraint	0.986614298

Proper Treatment of Citizens	0.986614298
Conformity	0.986614298
Attraction	0.998894443
Risk of Nuclear Terrorism and Human Error	-0.99999938
Behavioral Norms	0.986614298
NWS: Sovereignty	-0.99999254
Int'l Verification Agencies: Nuclear Security	1
NGOs: Oversight	0.99999995
NPT States: Equality	1
Outlier States: Prestige	-0.99890360
Promote Peaceful Nuclear Programs	0.99999995
Prevent Proliferation	0.999992547

Table 7.8: Mess Scenario 4 No Changes to Sovereignty, Signing of CSA

Component	**End State**
No stable end state, periodic flux This scenario remains complex	

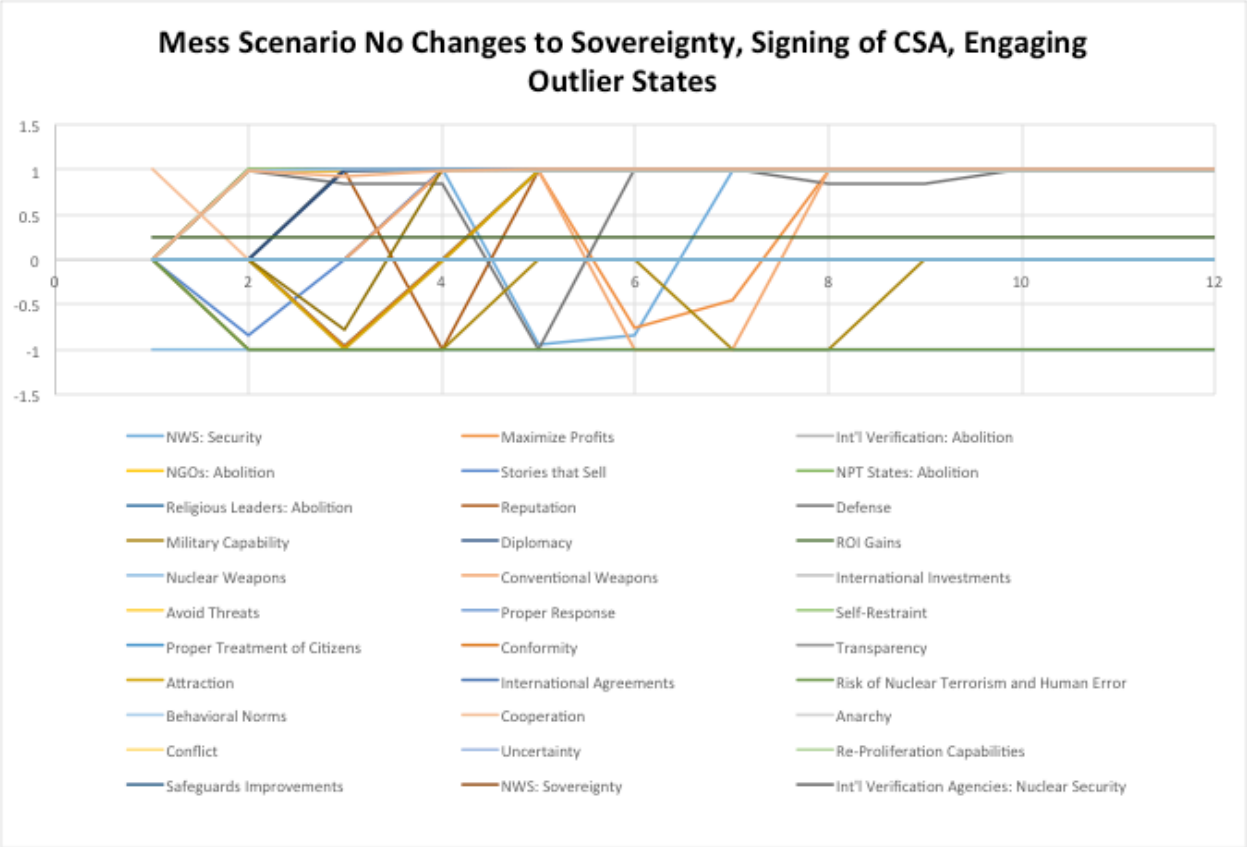
Table 7.9:Mess Scenario 5 No Changes to Sovereignty, Signing of CSA, Engaging Outlier States

Concept	**End State**
NWS: Security	0.999992546
Maximize Profits	0.99999995
Int'l Verification: Abolition	0.999999946
NGOs: Abolition	1
Stories that Sell	1
NPT States: Abolition	1
Religious Leaders: Abolition	1
Reputation	1
Defense	0.999992509
Military Capability	-0.00045401
Nuclear Weapons	-1
Conventional Weapons	0.999909197

Avoid Threats	0.999909204
Self-Restraint	0.986614298
Proper Treatment of Citizens	0.986614298
Conformity	0.986614298
Attraction	0.998894443
Risk of Nuclear Terrorism and Human Error	-0.99999938
Behavioral Norms	0.986614298
NWS: Sovereignty	0
Int'l Verification Agencies: Nuclear Security	1
NGOs: Oversight	0.999999388
NPT States: Equality	1
Outlier States: Prestige	0.25
Promote Peaceful Nuclear Programs	0.99999995
Prevent Proliferation	0.999992547

Given the five scenarios explored, the most feasible solution is to take steps that ensure states' rights under sovereignty are guaranteed, to bring the Outlier States into the fold, to seek the cooperation of nuclear weapons states through signing the Comprehensive Safeguards Agreement and the Additional Protocol. Under such a paradigm, states will feel more secure about their neighbors' intentions (however, uncertainty is an ongoing concern); Outlier States' needs will be recognized in the international community, reducing the probability that they will deviate from norms; and sovereign decisions, including the right to withdraw from existing or future treaties will not be affected (indeed, this is a requirement for any successful international agreement under the tenets of political realism). Equilibrium is reached relatively quickly. This scenario is illustrated in Figure 7.4.

Figure 7.4: Mess Scenario No Changes to Sovereignty, Signing of CSA, Engaging Outlier States



The constraints of this model of the "messy" nuclear landscape lead the research to a radical conclusion. Bringing in India, Pakistan, and the DPRK (Israel already enjoys substantial prestige, relative to the other three) seems counterintuitive. Indeed, less-powerful NPT states might reconsider their nuclear options if they feel the DPRK is rewarded for its nuclear weapons program. However, this simply suggests continued monitoring (or the Observe step) is necessary to prevent a Type IV error along these lines.

Paying closer attention to the needs of the Outlier States is not, however, as radical as it appears. When US President George W. Bush facilitated nuclear trade with India, it signaled a blow to nuclear safeguards and the NSG. On the other hand, the nuclear deal with India

benefitted safeguards in two ways. First, it brought substantial parts of India's nuclear sector under IAEA purview, including militarized nuclear sectors. Second, it signaled to the other Outlier States that cooperation with the P5 and NPT states is possible.

Additionally, paying closer attention to the Outlier States is not unreasonable. While none of the Outlier States are as powerful, as large, as near (not merely in the geographical sense) to the P5, or as nuclear as Russia, they are as demanding as Russia in other areas (in Problem 2 they were classified as *expectant* stakeholders). These states have unique needs that, under the status quo, are fulfilled by nuclear weapons as a proxy for what it wants most—a secure sense of power on an international stage,[354] a sense of power they feel is unjustly monopolized by the P5 and foolishly abandoned by the NPT.[355] Recalling that their priority in Problem 1 is identical to the nuclear weapons states (indeed, they were modeled with the nuclear weapons states) and that their divergence from nuclear weapons states in Problem 2 is a reticence towards following orders, the Outlier States have the capacity to follow trends as long as they feel like they are as equals in the driver's seat with an equivalent capability to forge new paths. And if Outlier participation makes the world more secure and less prone to nuclear accident or war, then each stakeholder walks away better than before.

On the other hand, and as mentioned earlier, continued monitoring is necessary to prevent NPT states seeking prestige. Nonproliferation might be a trend simply because few states believe the alternative is viable. If a small state not unlike the DPRK perceives DPRK inclusion as a reward for proliferating, then that small state can enact some level of gain by proliferating and

---

[354] Adapted from Simon Serfaty, "Moving into a Post-Western World," *Washington Quarterly* 34, no. 2 (2011): 10.

[355] Bull argues that resistance to the NPT by Outlier States is in part due to their needs not being addressed during negotiations; therefore, it is less likely they will agree to NPT revisions without taking part in the discussion. Headley Bull, "Rethinking Non-Proliferation," *International Affairs* 51, no. 2 (1975): 182.

then demanding status equal to the P5. Indeed, if the NPT regime's goal is one of equality, then it would not be irrational for all NPT states to seek prestige, as each state that joins the nuclear club experiences a diminished return because influence in the system is spread from a maximum of 100 percent, making the system more equal. Therefore, each individual nuclear-armed state's influence diminishes as additional states proliferate. This fits with the Waltzian model of horizontal proliferation, which, to the abolitionist, is not a preferred outcome. In fact, given that the NPT states' goal in Problem 1 is abolition, this Type IV error has a low probability of occurring.

At timestamp 0 nuclear weapons have been permanently reduced to -1. Sovereignty remains at 0. Outlier States are permanently lifted to 0.25. And Cooperation has an initial setting of 1. By timestamp 1 all stakeholders seeking abolition enjoy a maximum and permanent increase as a result of the signing of a disarmament treaty. Nuclear weapons states reputation significantly increase, due to their new role in the nonproliferation regime. Nuclear weapons states significantly increase their defense budgets, however, as a result of the massive defensive hole left when their nuclear deterrent was abolished, which is evident by the maximum and permanent decrease in military capability.[356] On the other hand, this decrease in military capability is offset because these states have avoided threatening behavior, thereby avoiding a security dilemma. The IAEA's twin goals to prevent proliferation and to promote peaceful nuclear capabilities enjoy a permanent maximization. The media's ability to sell stories declines, likely due to cooperation being less-than thrilling. And finally, the risk of nuclear terrorism is permanently eliminated.[357]

[356] It is permanent because these states permanently lose their ability to use nuclear weapons.
[357] This is unless a terrorist group can build a weapon independent of a state.

At timestamp 2 nuclear weapons states have maximized their security, due to the previous timestamp's threat avoidance and increased defense budgets. Production firms' profits slightly decline, due to the loss of nuclear contracts. The media's ability to sell stories continues to decline but stabilizes. Reputation and defense spending continue to rise. At this timestamp, however, previous nuclear weapons states suffer significant reductions in self-restraint, human rights, international conformity, and soft power, likely due to each states' needs to reassert its previous position without a nuclear deterrent. On the other hand, behavioral norms reaches a permanent maximization (i.e., the nuclear taboo has permanently extended to merely possessing weapons). NPT states permanently enjoy maximized nuclear equality. On the down side, at this timestamp, NGOs and activists suffer a significant reduction in their goal of oversight, due to the international community and the IAEA increasing their roles.

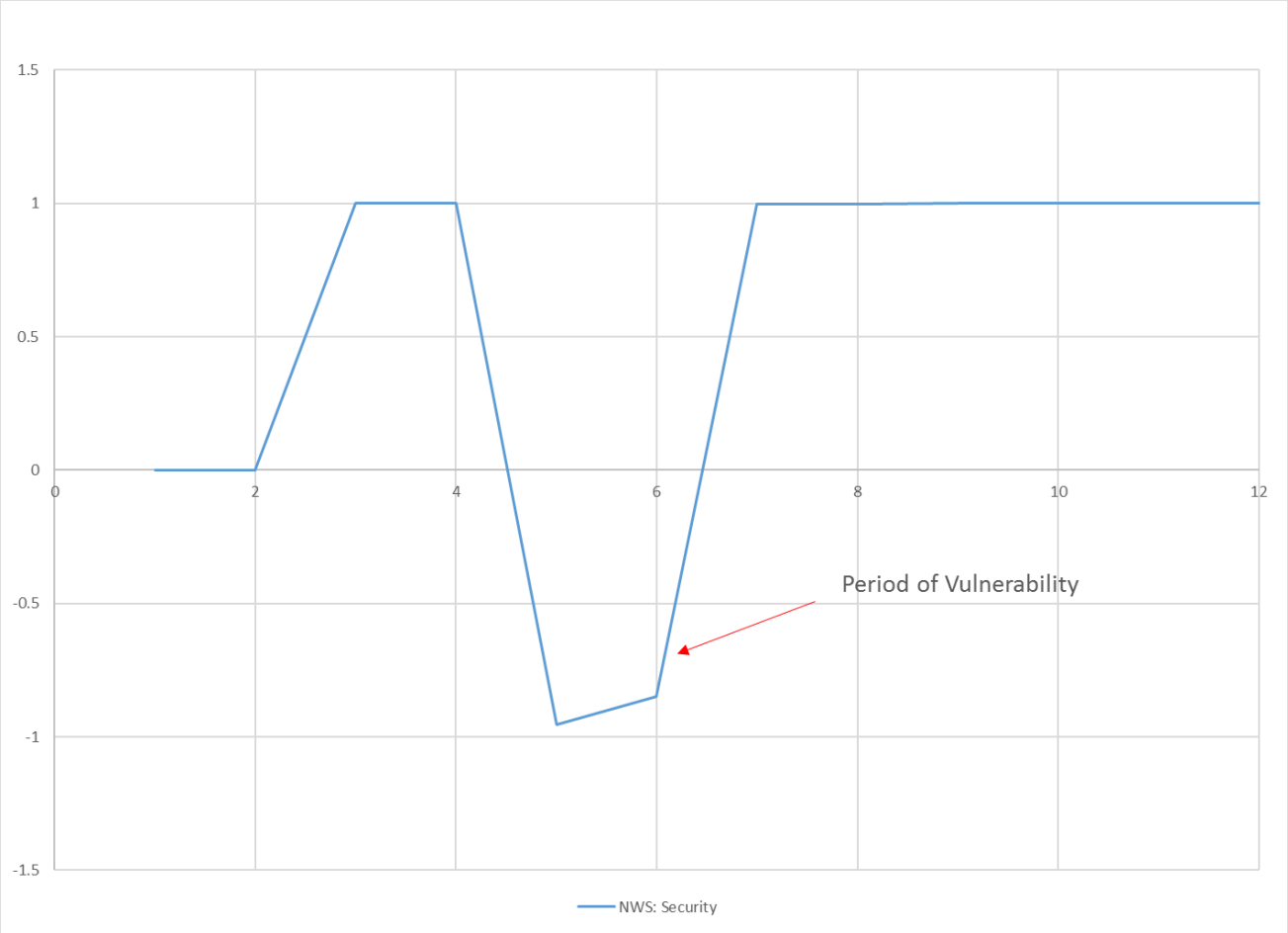
At timestamp 3 nuclear weapons states continue to enjoy maximized security. Production firms maximize profits due to previous increased defense spending. The previous timestamp's decrease in self-restraint, human rights, conformity, and attraction have caused a significant increase in the media's ability to sell stories and have significantly harmed former nuclear weapons states' reputations. Defense spending continues to increase. Self-restraint, human rights, conformity, and soft power continue to decline, but they are stabilizing. NGOs enjoy a significant and permanent increase in oversight.

At timestamp 4 a curious effect occurs. Nuclear weapons states' security significantly reduces (this is discussed more at length at timestamp 5). Production firms continue to enjoy high profits. Reputations finally and permanently increase due to timestamp 3's stabilizations of self-restraint, human rights, conformity, and attraction. Defense spending takes a large cut,

which might suggest former nuclear weapons states are slowing down defensive buildups. Self-restraint, human rights, conformity, and soft power all enjoy a permanent increase.

At timestamp 5 nuclear weapons states' security continues to significantly decrease. This decrease, which began in timestamp 4, can be referred to as the "security period of vulnerability," where former nuclear weapons states are vulnerable to the "Thucydides Trap" (discussed in the next chapter), due to previous timestamp's major increases in conventional weapons and new posturing (in the South China Sea and Eastern Europe, for examples) due to previous timestamp's reductions in self-restraint and conformity. This "period of security vulnerability" is highlighted in Figure 7.5. At timestamp 5 the disarmament treaty is in serious jeopardy, and at this point it might be reasonable for states to consider temporarily withdrawing from the treaty. Although this is not the desired outcome, it is preferable to World War III (and resultant nuclear proliferations anyway, which is also discussed in the next chapter). The model presented here, however, suggests the treaty will survive. Additionally in timestamp 5, production firms suffer a two-timestamp reduction in profits, caused by timestamp 4's reduction in defense spending. On the other hand, defense spending at this timestamp increases significantly and permanently.

Figure 7.5: Period of Vulnerability under Disarmament



By timestamp 6 nuclear weapons states have survived the threat of conventional war, and previous defense spending increases and abidance of various norms, such as self-restraint, human rights, and conformity (in addition to increased soft power), have permanently maximized the former nuclear powers' security. Production firms' profits continue to decline.

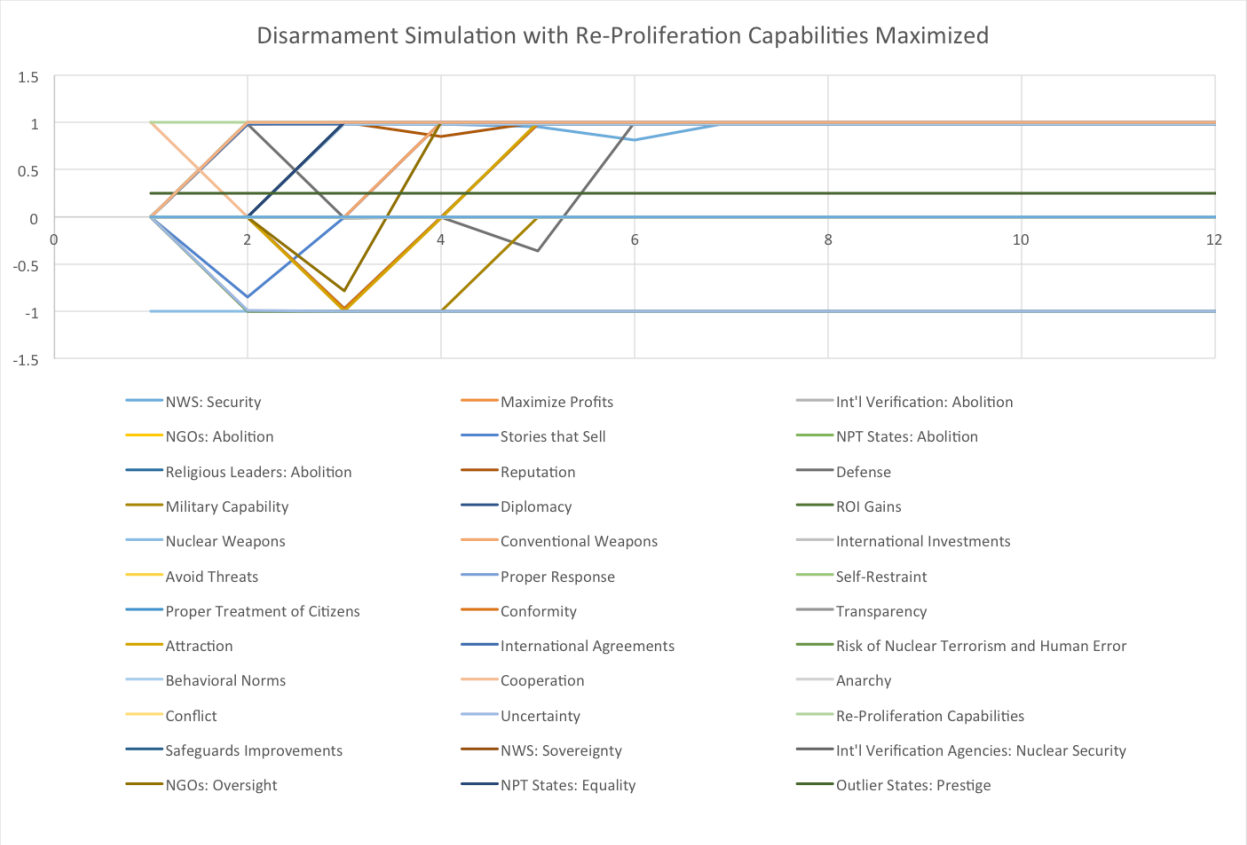
Finally, at timestamp 7 production firms' profits maximize, and the simulation reaches equilibrium by timestamp 8. As noted earlier, because the model is run according to the IAEA's schedule, each timestamp represents a year. Therefore, barring an unidentified error in modeling, and given that the problems do not change significantly, it is reasonable to conclude that all

stakeholders, including Outlier States, will benefit from a disarmament treaty within eight years of signing.

In this simulation the two primary objectives are achieved; security is maximized, and the IAEA achieves nuclear security. Of particular note is the null effect this simulation has on cooperation. The initial setting of cooperation to 1 has no lasting impact. Cooperation is not compelled; rather, it remains constant. Anarchy and uncertainty, too, remain unchanged. There are some added benefits. For example, states are better able to avoid signaling threat by mistake. On the other hand, military capability decreases for the simple fact that dismantling weapons by definition makes states incapable of using those weapons. This is countered by the very strong increase in defense, however, which suggests BOP politics will not end, but instead might become more pronounced, suggesting a possible Type IV error.

The identified "security period of vulnerability" is a serious hurdle, perhaps the most profound and likely of the possible Type IV errors. This is a period of time when militarized international disputes are very likely, culminating in a rush to rearm nuclear forces and, perhaps, a nuclear first strike to cripple the other side's nuclear capability. Therefore, I further hypothesize that the aforementioned re-proliferation capability be automatic and explicitly modeled in the simulation. In Scenario 6 I repeat Scenario 5 with "Re-Proliferation Capability" clamped at +1 to attempt to decrease uncertainty and shrink the period of vulnerability.

Figure 7.6: Disarmament Simulation with Re-Proliferation Capabilities Maximized



Scenario 6 is stable and complicated. The end state is very similar to Scenario 5's end state; however, some major differences exist. Transparency and the value of international agreements increase tremendously. This is largely due to the new significant reduction in uncertainty, which is itself caused by the knowledge that belligerence will be punished with automatic rearmament. This increase in certainty has an added benefit; it greatly reduces the security vulnerability, not in length, but in depth. This risk is not eliminated, but its intensity has been greatly reduced.

Figure 7.7: Reduced Vulnerability with Re-Proliferation Capability

Table 7.10:Mess Scenario 6 No Changes to Sovereignty, Signing of CSA, Engaging Outlier States, Maximizing Re-Proliferation Capability

Concept	**End State**
NWS: Security	0.999992542
Maximize Profits	0.99999995
Int'l Verification: Abolition	1
NGOs: Abolition	1
Stories that Sell	1
NPT States: Abolition	1
Religious Leaders: Abolition	1
Reputation	1
Defense	0.999908772
Military Capability	-0.00045401

Nuclear Weapons	-1
Conventional Weapons	0.999909197
Avoid Threats	0.999909204
Self-Restraint	0.986614298
Proper Treatment of Citizens	0.986614298
Conformity	0.986614298
Transparency	0.986614298
Attraction	0.998894443
International Agreements	0.986614298
Risk of Nuclear Terrorism and Human Error	-0.99999938
Behavioral Norms	0.986614298
Uncertainty	-0.99990292
Re-Proliferation Capabilities	1
NWS: Sovereignty	0
Int'l Verification Agencies: Nuclear Security	1
NGOs: Oversight	0.999999388
NPT States: Equality	1
Outlier States: Prestige	0.25
Promote Peaceful Nuclear Programs	1
Prevent Proliferation	1

In other words, this simulation thus far suggests that by recognizing existing sovereign rights, by bringing Outlier States into the fold, and by achieving universal adoption of the CSA and AP, disarmament will not disrupt the system, as designed.[358] Acting to achieve goals is feasible in this scenario. On the other hand, this does not exclude a Type IV error in the guise of states scrambling to rebalance the international anarchical environment.

[358] It must be noted that the fidelity present in this model cannot pick up individual disputes as identified by O'Hanlon. Simulations using agent-based modeling are better adept at handling both individual disputes and the international system. This is discussed more in the next chapter.

7.5 Final Simulations

Scenario 6 suggests there is a viable pathway towards disarmament by maintaining rights to govern the societies of their respective states, bringing in Outlier States to the negotiation process, signing the CSA and AP (as a measure of good faith, explained in more detail in the stability analysis), and substantially decreasing uncertainty by factoring into the solution rearmament capabilities that take effect automatically upon a former nuclear state's belligerence. Moving forward, one might ask oneself whether or not nuclear weapons can remain at -1 if the modeler removes the peg. Therefore, two final simulations are performed to test if the nuclear weapons node can naturally remain at a maximum level of decrease if all other variables remain constant.

In the first simulation, I clamp sovereignty, the Outlier States, and re-proliferation capability to their respective levels, per Scenario 6. All remaining components take on an initial value equal to their end state in Scenario 6 (shown in Table 7.9).

Table 7.11: Scenario 7 Stability After Disarmament

Component	Scenario 6 End State	Scenario 7 End State
NWS: Security	0.999992542	0.999992546
Maximize Profits	0.99999995	0.999999992
Int'l Verification: Abolition	1	1
NGOs: Abolition	1	1
Stories that Sell	1	1
NPT States: Abolition	1	1
Religious Leaders: Abolition	1	1
Reputation	1	1
Defense	0.999908772	0.999991878
Military Capability	-0.00045401	0.241457613
Nuclear Weapons	**-1**	**-0.95064491**
Conventional Weapons	0.999909197	0.999909197
Avoid Threats	0.999909204	0.99985127
Self-Restraint	0.986614298	0.986614298

Proper Treatment of Citizens	0.986614298	0.986614298
Conformity	0.986614298	0.986614298
Transparency	0.986614298	0.986614298
Attraction	0.998894443	0.998894443
International Agreements	0.986614298	0.986614298
Risk of Nuclear Terrorism and Human Error	-0.999999388	-0.999998998
Behavioral Norms	0.986614298	0.986614298
Uncertainty	-0.99990292	-0.99990292
Re-Proliferation Capabilities	1	1
Int'l Verification Agencies: Nuclear Security	1	1
NGOs: Oversight	0.999999388	0.999999388
NPT States: Equality	1	1
Outlier States: Prestige	0.25	0.25
Promote Peaceful Nuclear Programs	1	1
Prevent Proliferation	1	1

This scenario suggests the nuclear weapons node maintains a strong level of decrease. That is, by maintaining a strong commitment to not allowing the IAEA to grow too big, by maintaining a strong commitment to address the needs of the Outlier States, by continuing to be party to the CSA and Additional Protocol, which does increase the IAEA's scope but only through power granted it by member states, and by maintaining a strong commitment to re-proliferation when necessary, the role nuclear weapons play in our future scenarios will be significantly diminished (although not to the maximum degree possible).

In the second simulation I assign all components their initial values equal to the end states in Scenario 6 (again, shown in Table 7.9). That is, I remove all clamped values.

Table 7.12: Scenario 8 Nuclear Stability after Disarmament at a Cost

Component	Scenario 6 End State	Scenario 8 End State
NWS: Security	0.999992542	0.999992546
Maximize Profits	0.99999995	0.99999995
Int'l Verification: Abolition	1	0.999999946
NGOs: Abolition	1	1
Stories that Sell	1	1
NPT States: Abolition	1	1
Religious Leaders: Abolition	1	1
Reputation	1	1
Defense	0.999908772	0.99999251
Military Capability	-0.00045401	-0.00045091
Nuclear Weapons	**-1**	**-0.99999938**
Conventional Weapons	0.999909197	0.999909197
Avoid Threats	0.999909204	0.999909204
Self-Restraint	0.986614298	0.986614298
Proper Treatment of Citizens	0.986614298	0.986614298
Conformity	0.986614298	0.986614298
Transparency	0.986614298	0
Attraction	0.998894443	0.998894443
International Agreements	0.986614298	0
Risk of Nuclear Terrorism and Human Error	-0.99999938	-0.99999938
Behavioral Norms	0.986614298	0.986614298
Uncertainty	-0.99990292	0
Re-Proliferation Capabilities	1	0
NWS: Sovereignty	**0**	**-0.99999254**
Int'l Verification Agencies: Nuclear Security	1	1
NGOs: Oversight	0.999999388	0.99999995
NPT States: Equality	1	1
Outlier States: Prestige	**0.25**	**-0.9989036**
Promote Peaceful Nuclear Programs	1	0.99999995
Prevent Proliferation	1	0.999992547

Contrary to Scenarios 6 and 7, which suggest nuclear stability can be held as long as certain commitments are maintained, including a commitment to keep the IAEA from growing

too big, Scenario 8 suggests that following disarmament, the IAEA will be required to significantly increase its scope. While international compliance and verification naturally maintains their maximization under disarmament, and while nuclear weapons naturally maintain a maximum decrease (making them obsolescent) after disarmament, two costly effects are observed. Former nuclear weapons states' sovereignty is required to take a significant loss to maintain a nuclear weapons free world. Additionally, the Outlier States are required to take their own significant losses. These are highlighted with bold characters in the table above.

In other words, in Scenario 8, there emerges an IAEA that is more powerful than the sum of the power granted it by member states. This is approaching a Hobbesian solution, but built-in and automatic re-proliferation capabilities divorce it from the *Leviathan*. This capability is already built into both scenarios; therefore, Scenario 7 is far more feasible. IAEA empowerment should be limited to the scope of the milieu in which states find themselves. If disarmament is at any time preferable, states should work towards creating a milieu in which no one wants to possess nuclear weapons.

"Cooperation"

This model partially focuses on an initial maximum cooperative setting. Each subsequent timestamp allows the "cooperation" node to act according to the parameters of the model without user interference. What becomes obvious is that "cooperation" immediately falls to zero by timestamp 1. Therefore, this presents a good area to begin to test for sensitivity. While performing five sensitivity tests on "cooperation" according to Scenario 6 by varying the initial

state of "cooperation" to reflect all positive values "cooperation" can take, in addition to zero.[359] I note that varying the "cooperation" node has no observed effect. Rather, its inclusion is merely symbolic. To make the table simpler to read, I round all values.

Table 7.13: Stability with or without Cooperation

Scenario	**Cooperation = 1**	**Cooperation = 0.75**	**Cooperation = 0.5**	**Cooperation = 0.25**	**Cooperation = 0**
NWS: Security	1.00	1.00	1.00	1.00	1.00
Maximize Profits	1.00	1.00	1.00	1.00	1.00
Int'l Verification: Abolition	1.00	1.00	1.00	1.00	1.00
NGOs: Abolition	1.00	1.00	1.00	1.00	1.00
Stories that Sell	1.00	1.00	1.00	1.00	1.00
NPT States: Abolition	1.00	1.00	1.00	1.00	1.00
Religious Leaders: Abolition	1.00	1.00	1.00	1.00	1.00
Reputation	1.00	1.00	1.00	1.00	1.00
Defense	1.00	1.00	1.00	1.00	1.00
Nuclear Weapons	-1.00	-1.00	-1.00	-1.00	-1.00
Conventional Weapons	1.00	1.00	1.00	1.00	1.00
Avoid Threats	1.00	1.00	1.00	1.00	1.00
Self-Restraint	0.99	0.99	0.99	0.99	0.99
Proper Treatment of Citizens	0.99	0.99	0.99	0.99	0.99
Conformity	0.99	0.99	0.99	0.99	0.99
Transparency	0.99	0.99	0.99	0.99	0.99
Attraction	1.00	1.00	1.00	1.00	1.00
International Agreements	0.99	0.99	0.99	0.99	0.99
Risk of Nuclear Terrorism and Human Error	-1.00	-1.00	-1.00	-1.00	-1.00
Behavioral Norms	0.99	0.99	0.99	0.99	0.99

[359] I also ran these with "cooperation" set to negative values and noted identical results. It is not likely, however, that a successful disarmament treaty would show negative values of cooperation.

Uncertainty	-1.00	-1.00	-1.00	-1.00	-1.00
Re-Proliferation Capabilities	1.00	1.00	1.00	1.00	1.00
Int'l Verification Agencies: Nuclear Security	1.00	1.00	1.00	1.00	1.00
NGOs: Oversight	1.00	1.00	1.00	1.00	1.00
NPT States: Equality	1.00	1.00	1.00	1.00	1.00
Outlier States: Prestige	0.25	0.25	0.25	0.25	0.25
Promote Peaceful Nuclear Programs	1	1	1	1	1
Prevent Proliferation	1	1	1	1	1

There are two non-mutually exclusive ways to interpret this result: 1) Cooperation (signing the treaty) is meaningless in the short and long term. It is merely a symbol of what is possible at a specific point in time. 2) Cooperation holds no possession value for nuclear weapons states (or other stakeholders) but rather holds tremendous milieu value for stakeholders. These possession and milieu goals are discussed later. For now, states seek to attain possession goals to enhance national interest at the exclusion of others. In this case, security through nuclear capability is certainly a possession goal. Milieu goals are also for the enhancement of national interest, but not to the exclusion of others.[360] Participation in the signing of a disarmament treaty is a milieu goal; all international parties participating receive some benefit.

[360] Wolfers, 72-73.

7.6 Stability and Validation

Stability

To determine model stability, I re-ran several scenarios with varying new assumptions, one factor at a time. That is, I would tweak the end-state output of variable A to a different value along the Likert-type scale, searching for unexpected or expected emergence, as well as unexpected or expected non-emergence. If, for example, a minor change of a value from 0 to 0.25 has significant impact on the model, this might intensify uncertainty in the model. While running various scenarios I noted a few interesting developments, which will be discussed in turn.

First, I tested Outlier State prestige, holding constant all variation from Scenario 6, varying the Outlier State's prestige by values of 0.25 along the Likert-type scale. I noted that the model ran as expected. Minor variation does not affect the model's outcome. This is understandable because the Outlier States, according to the model's parameters, seek some level of prestige increase. Therefore, so long as the nuclear weapons states are paying attention to the DPRK and Pakistan, the model will perform the same. Additionally, if prestige is reduced to a negative value, then by no means has the nuclear "mess" been resolved, and the Outlier States will likely simply ignore a proposed resolution.

Next, I varied nuclear weapons. What happens if nuclear weapons' value increases by some number according to the Likert-type scale, but still retains a negative value? That is, what happens if nuclear weapons caches are simply reduced?[361] These scenarios performed as expected. As the nuclear redundancies are increased (nuclear reductions instead of abolition),

[361] For example, O'Hanlon posits a successful treaty will probably limit total nuclear warheads to 1,000. O'Hanlon, Kindle location 1249.

military capability increases dramatically. Movement from -1 to -0.75 (meaning 75% of warheads have been eliminated retained 84% military capability. Removing 25% of warheads retained 99% military capability. Running a scenario where nuclear weapons are not varied by initial state or clamping, I noted increased complexity, resulting in periodic flux. Under this scenario, equilibrium could not be reached and nuclear weapons alternate from ~1 to ~-1 from timestamp to timestamp. Therefore, discussion might be better shifted from arms control to disarmament.

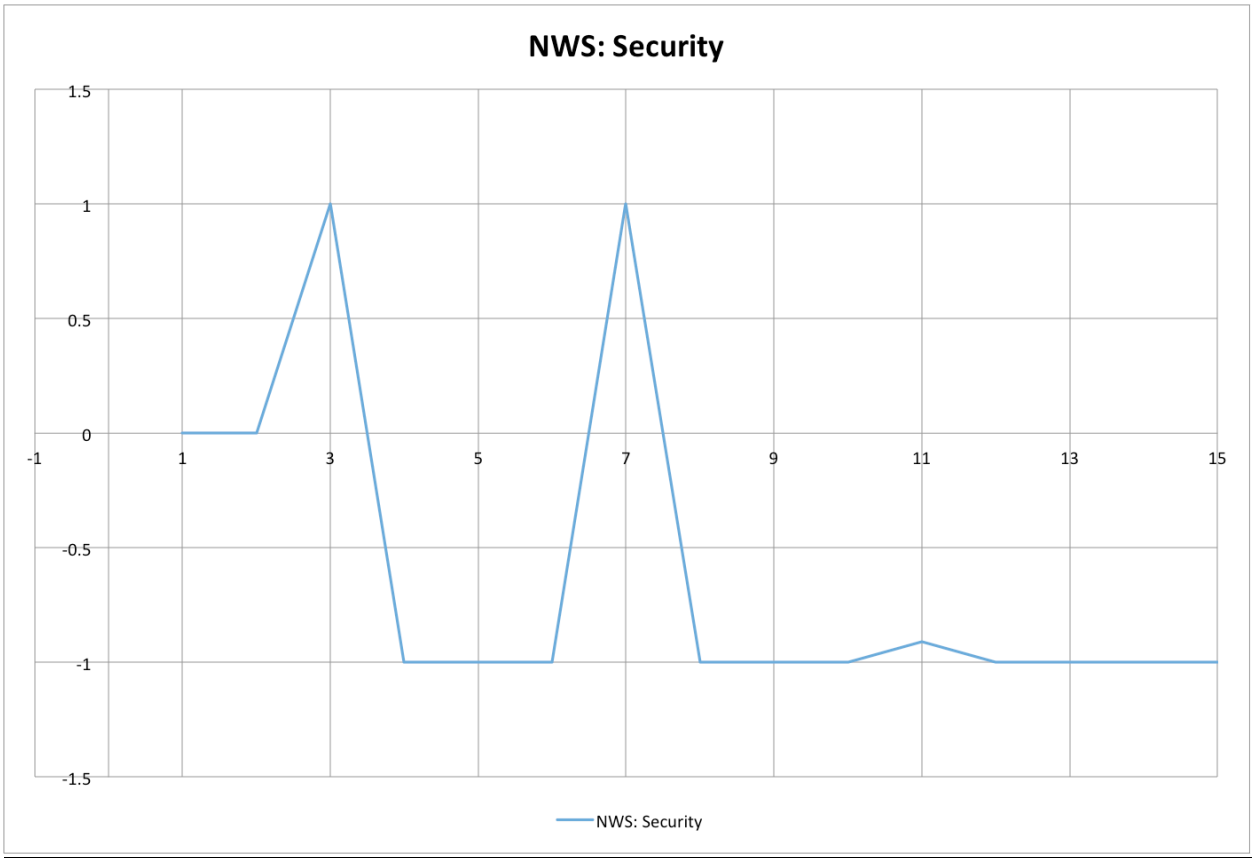
From here I shifted to varying degrees of sovereignty. What would happen if sovereignty were reduced or, somehow, increased? The simulations show there is no increased amount of sovereignty that affects the model in a negative way. That is, re-establishing sovereign capability through withdrawal from various non-disarmament treaties does not affect the disarmament treaty. Decreasing sovereignty does not affect model performance either; the IAEA, NPT States, and NGOs certainly would benefit from reductions in nuclear weapons states' abilities to function independently of the international environment. On the other hand, sovereignty, according to the model, only maintains its status quo through clamping it to zero. If left to its own devices according to the parameters of Scenario 6, the IAEA will assume total jurisdiction in the former nuclear-armed states, resulting in greatly diminished ability to govern as one sees fit.

I then ran two simulations where I greatly reduced the IAEA's influence in the model or greatly increased it. That is, if there was a link between the IAEA and another component, the IAEA's abilities were either erased (zeroed out) or maximized to +1 or -1. Zeroing out the links resulted in, as expected, increased complexity without model equilibrium. Without the IAEA to verify compliance through increased technological and legal mechanisms, leaving disarmament

up to the whims of anarchy greatly destabilized the system. Maximizing the IAEA's affect along already-established links was offset by the nuclear weapons states' unchanging goal of sovereign right.

Re-proliferation is, as expected, a key variable that increases security through diminished uncertainty. For example, reducing automatic rearmament capability to 0.5 requires reduced transparency. If the scenario is run with re-proliferation clamped to -1 (meaning, somehow nuclear know-how has been erased from human memory), then there are significant reductions in state security, profits, the IAEA's missions (which makes sense), NGOs ability to influence problem resolution, equality within the international system, defense, military capability, conventional weapons stockpiles, self-restraint, human rights, conformity, transparency, soft power, and the value of international agreements.

Figure 7.8: Instability without Re-Proliferation Capability



I finally tested what effect disarmament would have in the status quo. That is, what would happen to security if we attempt to rid the world of nuclear weapons without dealing with the half-dozen or so ongoing international geopolitical disputes? I clamped "conflict" to 1, finding equilibrium (in the model) is reached, but it requires significant decreases in security, defense, military capability, and conventional forces. In other words, the model performs as expected; under this scenario and the one preceding it, I have created World War III.

Validation

In the stability tests, the model performed as expected. There are no overly sensitive links, and sensitivity exists where it is anticipated. The IAEA is not too empowered, and the re-proliferation capability emerges as a key variable towards security, which complicates the IAEA's mission towards permanent abolition. This sensitivity test goes hand-in-hand with validation. That is, there are no surprising results that reality disputes. The question before us now is: To what degree does the model reflect the "mess" and its constituent problems?

Lewis F. Richardson noted that human behavior "cannot be properly described by linear equations."[362] Human behavior is multitudes. It is contradictory, often random, and too generalized to be solvable by computable numbers.[363] To that end, Sterman is correct when he writes, "All models are wrong." He argues,

> Because all models are wrong, we reject the notion that models can be validated in the dictionary definition sense of 'establishing truthfulness', instead focusing on creating models that are useful, on the process of testing, on the ongoing comparison of the model against all data of all types, and on the continual iteration between experiments with the virtual world of the model and experiments in the real world.[364]

---

[362] Lewis F. Richardson, "Linear Theory of Two Nations," in *Collected Papers of Lewis Fry Richardson*, ed. Oliver M. Ashford, H. Charnock, P. G. Drazin, J. C. R. Hunt, P. Smoker, and Ian Sutherland (New York: Cambridge University Press, 1993), 268.
[363] Adapted from Turing, 246.
[364] John D. Sterman, "All Models Are Wrong: Reflections on Becoming a Systems Scientist," *System Dynamics Review* 18, no. 4 (2002): 521.

A useful model, he adds, "must address a specific problem and must simplify rather than attempting to mirror in detail an entire system."[365] It is for this reason that model design does not attempt to capture the entire international system in which the nuclear "mess" exists; rather, it attempts to resolve the interactions between specific problems within the system. A better question might be: To what degree will this model teach practitioners about the nuclear "mess"?

Because this model attempts to be useful to current or future practitioners rather than a valid representation of the system in which the practitioners operate, it must not merely represent the problems and the "mess;" it must *interact* with the actual problems and the actual "mess." Therefore, "validation" comes from how useful it is in the real system. Proving its use is to prove it is not invalid rather than to prove it is valid.

The model I present is a more-or-less simplistic representation of highly complex issues in international relations. Yet, it captures significant cause and effect, often only sacrificing fidelity to appease the Waltzian realists. More model complexity will certainly benefit model performance to some degree, but this requires model interaction with the real world, which has an unfortunate effect of undermining model validity.

That is, in a perfect world I would have a large conference room on reserve for a week or two and accommodations made for dozens, if not hundreds, of global decision-makers, from presidents to the Director General of the IAEA, all manners of stakeholders, each with natural levels of influence to resolve the "mess." I would ask them to help re-construct this fuzzy cognitive map, each mapping out his or her place within the problem, based on experiences to which they can attest. They would incorporate the FCM methodology laid out in the previous

---

[365] John D. Sterman, "A Skeptic's Guide to Computer Models," reprinted from *Managing a Nation: The Microcomputer Software Catalog*, ed. Gerald O. Barney, W. Brian Kreutzer, Martha J. Garrett, W. Brian Kreutzer (Boulder, CO: Westview Press 1993), 209-229.

chapters completely. What is their goal? What forces are helping them achieve their goal? What forces prevent them from achieving it? This goes on until they are satisfied that their needs and influence are represented. But seated next to a British delegation is a delegation sent by Greenpeace. Each draws their FCMs, but one stakeholder holds more power than the other. Furthermore, each stakeholder has a different view of what reality is. As their FCMs come together and nodes between them identifired, they might disagree on the effect Greenpeace has on the United Kingdom's nuclear weapons program. This example might be less-than meaningful due to obvious differences in influence. What happens, therefore, when actors of similar influence compare FCMs? Certainly, NGOs and NPT States will disagree on who has more influence on the nuclear weapons states. NGOs can operate between states, and their lobbies are often powerful. NPT States and Outlier States might furthermore disagree on who holds more influence. In other words, simply put,

> The question of whether some cognitive maps represent reality better than others might not be possible because the reality with which the model outputs are compared is mediated through yet *another understanding*.[366]

The mere fact that no two stakeholders understand the world identically means there is likely to be great variation between stakeholders' views of how the model should work and what good output looks like.

That stated, this problem with validity does not mean the model is less-than useful. In the aforementioned perfect world, the model constructed here is a simple demonstration of cause and

[366] Emphasis added. Uygar Özesmi and Stacy L. Özesmi, "Ecological Models Based on People's Knowledge: A Multi-step Fuzzy Cognitive Mapping Approach," *Ecological Modelling* 176, no. 1 (2004): 57-58.

effect that all stakeholders can understand, particularly if one goes beyond the model's current parameters and includes costs levied by even a small nuclear war, as illustrated in Chapter 2. It furthermore invites debate between the stakeholders. The validity problem means that stakeholders involved in a future version of this model will have the ability to reason through their various levels of influence and the differences between them. They will be better able to critically evaluate their capabilities the components driving and preventing the attainment of their individual goals.

Furthermore, the FCM is explicitly limited by present reality. As the situation changes, as new stakeholders emerge or established stakeholders decline, and as stakeholder capability varies, so too do the model's assumptions. The FCM designed here is not merely subject to rigorous scientific standards; it is also subjected to ongoing rigorous changes to reality. Much like the real world around it, it evolves, unlike Lewis F. Richardson's arms race model.

Finally, due to its ability to evolve as real-world timestamps progress, and because a model within a perfect world will have real-world stakeholder input, a demonstration not unlike the one I make in this study should appease all stakeholders. All stakeholders receive some benefit from partaking, flexing their milieu goal muscles.

7.7 Summary

This chapter seeks to determine if the two problems from the preceding chapters can be solved simultaneously to avoid making a Type IV error. It identifies each of the "mess'" constituent problems, restructuring the "mess" so that interaction between them becomes more apparent. Several scenarios are run, and finally, a feasible solution is uncovered.

First, any future disarmament negotiation must respect that the IAEA cannot become too empowered. States still dominate the international system. Any states party to the treaty will not be intruded upon in areas outside of the agreement, and these states can furthermore choose to withdraw from the treaty if they later wish to do so. Second, special attention should be paid to the Outlier States, bringing them into the negotiation process, and treating them as equal to the P5. Third, security is best (and perhaps only) guaranteed through a guaranteed and automatic rearmament process to re-establish certainty in international affairs. Once these steps are taken, a symbolic treaty can be signed that weds the nuclear weapons states to the CSA, the AP, and Article VI of the NPT; the disarmament process can begin.

This process is not without its potential problems, however, and these potential Type IV errors are identified and discussed in the next chapter.

CHAPTER 8

DEALING WITH THE UNKNOWNS

8.1 Possible Type IV Error

In the previous three chapters, I construct the "mess" by modeling two problems and the interaction between the problems. Running several scenarios, I determine that a feasible way to disarm is to prioritize the universal signing of an international treaty that weds states to the Comprehensive Safeguards Agreement with Additional Protocol; maintaining guarantees that the treaty will infringe on sovereign governance to the least degree possible; bringing in outlier states, such as the DPRK and India, during the negotiations for disarmament, and establishing automatic mechanisms to reconstitute nuclear capabilities if and when new international crises develop. Once these steps have been taken, international nuclear diplomats will have a stable, but complicated, landscape in which to begin the long process down to global zero. But the debate between nuclear realists and nuclear moral crusaders along nuclear security lines is filled with hazards, pitfalls, and structural forces that construct all manners of unfortunate complications. From security dilemmas to Hobbes' and Thucydides' traps, the constructed mess is—in reality—a landscape where practitioners would be wise to tread very lightly. As students from almost every academic field learn, sometimes actors with good intentions cause catastrophe.[367]

---

[367] In 2000 New Mexican officials started a controlled burn to reduce fire hazards at the Bandelier National Monument. The controlled burn became uncontrolled, and the result was about 48,000 acres burned, the displacement of 400 families, and almost a billion dollars (in 2000 US dollars) in damages. In April 1999 NATO forces targeted a railroad bridge near Grdelica, Serbia that was used to provide supplies to Yugoslavian fighters. A commuter train carrying dozens of civilians crossed the bridge at the precise moment the rocket intercepted the bridge. At least 20 civilians were killed, and the damage to the bridge (due to a train being in the way of the rocket) was minor enough that it was only out of commission for a few months. In 1218 Shah Muhammad II of Khwarezm received notice from an envoy that Genghis Khan

Multiple error types often cause catastrophic accidents under the best intentions. Actors might have misinterpreted data, formulated wrong problems, or merely choosing the wrong solution. Often, the Type IV error is at least partially to blame.[368] Simply put, actors can make their situations worse. In this study, supposing that the previous chapters have formulated the correct problems and "mess" as they stand today, a very real potential Type IV error is glaringly obvious. As discussed previously, O'Hanlon makes reference to this error when he insists that disarmament negotiations should wait until there have been significant reductions in specific international disputes, disputes that cannot be captured in this model's fidelity; however, each dispute might benefit from practitioners' use of FCM.

If the world were rid of nuclear weapons by design before the end of 2019, what would happen in 2020 to—for example—security guarantees the US and NATO provide to former Eastern Bloc states? If Russia were no longer deterred from going further into Ukraine or Georgia, would Russia decide to annex territory? While I do not attempt to predict Russia's behavior in a disarmed world, there are several side effects of the disarmed world that practitioners would be wise to take under consideration. Furthermore, if the world were suddenly void of nuclear weapons tomorrow, how close to parity would China be to the US in terms of

---

wanted to open bilateral trade. Believing this to be a ploy precipitating an attack, the Shah arrested the envoy. Khan sent a second envoy in an attempt to open up diplomatic negotiations. The shah had this envoy executed. Khan finally retaliated by attacking the Khwarezm, completely annihilating the society. In January 1969, in an effort to mobilize fellow Czechoslovak citizens to protest and rise up against the recent Soviet Occupation, Jan Palach, a young college student, set himself on fire, inspiring a violent uprising against the Soviet Army. The dissenters were outmatched, and the Czechoslovak middle class disavowed the protestors' violence. Palach died in vain. In 1958 Communist Party of China Chairman Mao Zedong created a labor policy that favored industrial production over the agrarian economy. His effort to modernize China's industry sector, along with drought and other poor weather patterns, contributed significantly to the Great Chinese Famine, which lasted two or three years and killed 15 to 30 million people.

[368] To refresh, the Type IV error is when you correctly solve one problem but make another problem worse.

power? And how would the Chinese-US dynamic change under these new conditions? If one looks at these potential effects individually, they are huge. If these effects compound the other, they are astronomical. If Russia moved into Europe, and if China sought to dramatically expand its military presence in the South China Sea or to finalize its sovereign claims over the Senkaku Islands against Japan, or if the US worried China was making significant advances on its hegemonic position in terms of military power, it could be the rumblings of World War III, due precisely to the loss of MAD.

In any event, O'Hanlon argues for a re-proliferation clause in a future disarmament treaty that will be immediately and automatically enacted to quickly reduce the risk of major war—wars that might result in a rush to build new nuclear weapons, culminating in at least one side using at least one on the battlefield. In other words, O'Hanlon's re-proliferation clause would be wise for at least two reasons: 1) It can mitigate major conflict, and 2) states are likely to re-proliferate during the outbreak of major conflict anyway, which could have disastrous effects if not preemptively managed through the disarmament treaty. MAD is certainly preferable to WWIII and nuclear annihilation.

Therefore, this section attempts to overcome the limits of the model by discussing why disarmament, even under conditions set forth by the model, is likely only viable given major reductions in international disputes and uncertainty. This section examines the theoretical implications in terms of disarmament of balance of power with a global hegemon, the roles presently-nuclear states might play in a disarmed world, the major disputes that must be overcome prior to a successful (and Type IV error-avoidant) disarmament treaty, the benefits of a re-proliferation clause (including a hypothetical scenario), and overcoming the Thucydides'

Trap with the IAEA. Later in this chapter, I discuss lingering uncertainties and the model's remaining limits.

8.2 Thucydides and Power Balancing

The foundational text on the logic of realism, power shifts, and war is Thucydides'' *The History of the Peloponnesian War* (431 BCE). Thucydides, an exiled Athenian general during the Peloponnesian War, provides one of the war's only historical, eyewitness[369] accounts. Although he does not cover the war's conclusion, he provides remarkable insight into a long and bloody war from antiquity—a war, we find from sources beyond Thucydides that resulted in the destruction of two kingdoms, Athens and Sparta, and culminated in the severely weakened Sparta claiming a short-lived victory. The spark, writes Thucydides, that set the whole Aegean Sea ablaze was a shift in the traditional balance of power.

Sparta, a warrior culture and the dominant military power comprising the Peloponnesian League, maintained a tepid peace with Athens, a sea faring, trading nation. While Sparta was certainly the more powerful state, Athens had been enjoying significant growth, both economically and in terms of military power. In fact, Athens had accumulated, through purchase and alliance, a naval force consisting of hundreds of ships. This, along with Athens' decision to rebuild its city walls following the Spartan-Athenian victory over the Persians, added stress to the fragile truce. Thucydides, desiring that future diplomats avoid costly wars, takes the reader through the difficult—and seemingly impossible—diplomatic crisis while everyone involved tried in vain to prevent an "inevitable" war. He writes, "The real cause [of the war] I consider to

[369] Thucydides' finer points should be taken illustratively; it is unlikely he attended every meeting he claims took place.

be the one which was formally most kept out of sight. The growth of the power of Athens, and the alarm which this inspired in Lacedaemon [Sparta], made war inevitable."[370]

Thucydides, injecting mild hyperbole, picks up on a dynamic that has shaped international relations as far back as the human race can remember and as far forward as the human race can imagine. "Balance-of-power politics," as Waltz puts it, "prevail whenever two, and only two, requirements are met: that the order be anarchic and that it be populated by units wishing to survive."[371] Thucydides recognized a third requirement: Fear (or "alarm," as it is put in Richard Crawley's translation). I make few distinctions between (Thucydidean) classical realism and (Waltzian) neorealism. Rather, suffice it to say that both theories are compelling arguments. Realism, as a general definition, explains the world of politics around us. And if the Thucydidean trap is good prediction, therein lies trouble for the US and China in a world no longer ordered through nuclear deterrence.

Allison Graham notes, "Intentions aside, when a rising power threatens to displace a ruling power, the resulting structural stress makes a violent clash the rule, not the exception."[372,373] He calls this phenomenon the "Thucydides Trap," a term since adopted by diplomats and academics, from General David Petraeus to Henry Kissinger to former Deputy Permanent Representative of China to the UN, Wang Xuexian. Graham notes sixteen cases of balance of power shifts during the previous five centuries. In twelve of those cases, the rise of the challenger resulted in war. In only four cases, the challenger rose in terms of power without

---

[370] Thucydides, *The History of the Peloponnesian War*, translated by Richard Crawley. Kindle Edition (431 BCE), 10.
[371] Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: Addison-Wesley Publishing Company, 1979), 121.
[372] Allison, Kindle location 149.
[373] This Kindle edition is formatted unconventionally. Some pages are marked as "location," which is *not* the page number, while others are marked with "page." I have taken care to distinguish between the two by labeling locations as "Kindle location."

disrupting the relative peace. In other words, all other things equal, war between a rising China and a declining US has 3:1 odds of occurring when the states reach power equilibrium, if history is any indicator. While China balances both in terms of traditional power as well as economically,[374] the prior would be the main consideration in a world devoid of nuclear weapons.

If nuclear weapons maintain the peace by defining cause and effect in no uncertain terms, then how much certainty would China have in the South China Sea or the Senkaku Islands if 1) nuclear weapons did not exist, and 2) two sides in dispute had robust conventional forces? More important, how certain could a US encroacher in these maritime regions be that a Chinese military buildup was not a precursor for a Chinese military campaign against the US or its allies? Another way to put it is: If nuclear weapons are abolished tomorrow, the difference of power between the US and China would be narrowed significantly, along with the expected costs of all-out war. If we trust Thucydides, or more modern writers such as Powell,[375] this would put tremendous stress on the US to reduce China's military capability. And if the Peloponnesian War is an indicator, we can imagine a world where China and the US reduce each other's power through a protracted war, and Russia gaining absolute advantage over both its adversaries. And because China and the US are aware of this possible future, it can, at the first hint of malicious intent, invoke re-proliferation, leading to a re-proliferation cascade.

---

[374] Blackwill and Harrison write, "Beijing is often correctly described as the world's leading practitioner of geoeconomics, but it has also been perhaps the major factor in returning regional or global power projection back to an importantly economic (as opposed to political-military) exercise." Robert D. Blackwill and Jennifer M. Harrison, *War by Other Means: Geoeconomics and Statecraft* (Cambridge: Harvard University Press, 2016), 11.

[375] Robert Powell, *In the Shadow of Power: States and Strategies in International Politics* (Princeton: Princeton University Press, 1999).

Allison notes, through examination of the power shifts that did not result in war, a rising China does not necessarily mean there will be war with the US. The states can avoid this war; given both states acknowledge two difficult truths. First, the current trajectory *is leading to war*. Second, war is not necessarily a resultant conclusion of power shifts.[376] Furthermore, the US and China must increase dialog, engage in constant dispute resolution, and, most important, seek to change attitudes and actions.[377] While Allison is writing about the status quo—a world where both China and the US have nuclear weapons[378]—these acknowledgements and actions are even more necessary in a world where neither have nuclear weapons.

The role of the US and NATO in Europe is another potential for major war in a non-nuclear world. In 2008, following increasing unrest from Abkhazian and South Ossetian separatists, Russian military forces invaded Georgia and occupied these territories. In 2014 the Russian Federation annexed Crimea from Ukraine, following a violent Ukrainian revolution that ousted the pro-Kremlin president. Of particular note are the strong Russian links between Russia and the annexed or occupied territories. Crimea's population, for example, was over 65% ethnic Russian in 2014. This contrasts with Ida-Viru County, Estonia, with an ethnic Russian population at over 73%. What differentiates Ukraine from Estonia is Estonia's membership in NATO, which, on paper, guarantees Estonia's security through Article V, also known as the collective defense article in which NATO member states will militarily defend all of its member states. Ukraine and Georgia have no NATO membership or collective security guarantees. In a nuclear world Russia's cost of going to war with NATO by invading or attempting to annex Ida-Viru greatly outweighs its benefit. If the cost of a nuclear attack is removed from Russia's

[376] Allison, Kindle location 190.
[377] Allison, Kindle locations 224-230.
[378] Where, "Chinese and American leaders know they cannot let [nuclear war] happen." Allison, 155.

calculus, it might feel the benefit of annexing Ida-Viru outweighs the cost. If Russia invaded any neighbor following global disarmament, particularly a NATO member, NATO, or more specifically the US, would be left with either accepting the new status quo, thus rewarding Russia for deviant behavior, or entering a costly war. Again, this scenario does not rule out the possibility of re-proliferation. Therefore, the resolution of this dispute takes high precedence before any disarmament treaty can be signed.

The Kashmir conflict between India and Pakistan,[379] two nuclear weapons outlier states, is another dispute requiring immediate resolution. This became apparent in the previous chapter when the needs of Outlier States became a necessary consideration. This dispute has been ongoing for over seventy years, with periodic wars and skirmishes (some of which have occurred *after* both India and Pakistan proliferated nuclear weapons[380]). This dispute is further complicated and has become more important to resolve due to the entrance of non-state actors and jihadist groups, such as al Qaeda and Hizb-ul-Mujahideen. These non-state actors could inherit nuclear weapons programs if they grew strong enough to pose a credible threat to existing or future regimes.

Three other ongoing disputes need attention, but their resolutions might not be necessary prior to disarmament treaty negotiations. First, Israeli-Arab/Iranian disputes in the Middle East complicate satisficing capability. On the one hand, Israel's nuclear weapons program provides the Jewish state with negotiation leverage that Arab states and Iran do not possess. Furthermore, Israel's nuclear weapons program is not necessarily viewed as a guarantor of its survival but rather a dead man's hand in the event that it feels its existential security is about to be reduced to

[379] In February 2019, this conflict reached crisis heights, demonstrating that February 2019 is not the correct time to have an India-Pakistan disarmament discussion.
[380] This should insinuate that both India and Pakistan are willing to fight wars, despite the threat of escalation.

zero. Its program, while the ultimate deterrent, is also means of revenge in the case of defeat. This does not imply that negotiating Israel's disarmament is impossible. Israel could follow the South African model, identified in the previous chapter. In the event that Israel achieves a true and lasting peace with its neighbors, finds reconciliation with Palestinians with legitimate land claims within Israel's borders and along the West Bank and Gaza, and enters into a legally binding collective security arrangement with the US (or, albeit unlikely, a collective security regime within the Middle East) then it is reasonable to hypothesize that, like South Africa following its threat relief, Israel could find that nuclear weapons no longer serve its needs.[381] Another area of concern in the Middle East is the possible proliferation of Arab states or Iran. Several of these states, including Iraq, Iran, Syria, and Libya have had *bona fide* nuclear weapons programs that have been curtailed or halted. Therefore, a disarmament treaty should address these states' security needs.

Second, there is the issue with Taiwan's security. It is not difficult to imagine that, with the US losing its nuclear deterrent, China moves significant conventional forces to the island and self-fulfills its territorial claims. Because Taiwan is aware of this threat, it might consider its own nuclear deterrent, particularly if the US reduces its commitment to Taipei as part of negotiations with China.

Finally, the ongoing dispute between the ROK and the DPRK is the last major area of concern. Recent events, however, suggest that Kim Jong Un is willing to discuss disarmament if its security concerns are alleviated. The environment of the post-2018 Winter Olympics in PyeongChang, ROK is skeptically optimistic. Kim and ROK leader Moon Jae In have made significant progress, relative to the preceding decades. US President Trump has furthermore

[381] Unlike South Africa, however, Israel's nuclear weapons do not face universal condemnation.

brought the DPRK into the spotlight[382] and demonstrated that the West takes its needs seriously, which, as Problem 2's modeling indicated, is a requirement for a successful treaty.

At a minimum the major issues need to be addressed.[383] Beyond that, resolution of secondary issues makes the "mess" less messy, which would benefit future practitioners. Because the model in the previous chapters cannot account for these international disputes, it does not consider them while determining if $\max\left(\frac{Benefit}{Cost}\right) \geq 1$ has been satisfied. Therefore, borrowing from O'Hanlon, "The right time horizon for seriously pushing a new nuclear accord is when most of the world's half dozen or so major territorial and existential issues are resolved—and this cannot be set to a calendar as precisely as the Global Zero movement would like."[384] In other words, while the previous chapter's models suggest intervention is warranted and possible in the present, a more holistic view of the problems reveal serious hurdles that could result in one or more error types if action is taken prior to their resolution, particularly a Type IV error—World War III (followed by systemic re-proliferation).

In summary of the above, Allison agrees with O'Hanlon in prescription.[385] Preexisting disputes must be resolved before disarmament treaties can be negotiated.[386] Although this level of fidelity does not appear in my model, it must be implicit.

---

[382] Trump is the first US president to meet with and acknowledge the legitimacy of a DPRK leader.
[383] O'Hanlon writes, "Once these contentious matters are largely resolved, the plausibility of great-power war over any imaginable issue that one can identify today will be very low." O'Hanlon, Kindle location 985.
[384] O'Hanlon, Kindle location 117.
[385] Recalling O'Hanlon's concern about Kashmir, the South China Sea, and NATO-Russia relations. O'Hanlon, Kindle locations 1036, 1040, and 1080.
[386] Treaty negotiation must not be clouded with unnecessary stipulations; therefore, it is unwise to attempt to settle these disputes as part of the disarmament negotiation process.

8.3 The Type I Error and the Benefits of Re-Proliferation

Thucydides' observation on human behavior is, at its core, that humans are inclined to commit the Type I error (a false positive) due to evolutionary pressures selecting individuals that take precautions. As mentioned in earlier, committing the Type I error can be costly, but committing the Type II (the false negative) error can be deadly. While Sparta suffered great cost by incorrectly assuming Athens had malicious intent in building fortifications and its naval forces, Sparta could have lost significantly more if Athens continued to build its power, unchecked, until it could easily defeat Sparta (for example, through a naval blockade and scorched earth tactics).

Realism, both classic and new, is also the proposition that states are more likely to make the Type I error than they are the Type II error. Both variants of realism are concerned with survival, but the former focuses on fear as a driving force towards the Type I error, while the latter focuses on cost-benefit calculations.

Suspecting danger is a natural condition in human affairs. Early morning joggers often cross the street to avoid the unfamiliar dog taking her morning walk, despite its tether. Police officers must constantly choose between making the Type I and Type II errors when facing belligerent suspects (a Type I error might result in criminal charges against the officer, while a Type II error might result in a flag-draped coffin). In international politics, the US committed the Type I error when it erroneously assumed Saddam Hussein had a weapons of mass destruction program. Iraq committed a Type II error when it erroneously assumed the US would not retaliate against insubordination towards IAEA inspectors. If it had risked the Type I error, Saddam might have remained in power until his natural death. Most profoundly, the US committed a Type I error when it erroneously believed Nazi Germany was actively seeking atomic weapons during

WWII.[387] And the belief that another state might harm you with nuclear weapons is a good reason to seek nuclear weapons of your own.

In this sense it can be surmised that, given the model parameters, and given holistic treatment of the system (solving ongoing disputes prior to acting), then periodic nuclear reconstitution can be a good thing. This self-fulfilling prophecy tests the problem's limits and quickly restores order in the event of crisis. The following hypothetical scenario illustrates the point.

I imagine that in the distant (but not too distant) future, major disputes in international affairs have been resolved or largely mitigated. The nuclear weapons problem remains structured as it was in the 2010s. Ukraine has little reason to worry about further Russian encroachment. Kashmir is satisfied with its new arrangements. Iran has enjoyed years of economic and nuclear diplomacy—expanding the BRICS to the BRIICS—and poses no major threats to Israel, which also enjoys new peace arrangements with the Western-backed regimes to arise from the ashes of the Arab Winter. China, following tense negotiations, and after overtaking the US as the most dominant economic power in terms of power purchasing parity *and* actual gross domestic product, has agreed to a maritime treaty that benefits all stakeholders (using fuzzy cognitive mapping, of course). The US has spent years investing in computer science and has emerged as the global network security provider. The Koreas have been engaging in ongoing peace talks. Kim Jong Un's heir apparent has just finished her first year at university in Geneva. Although few new democracies have entered the community, at the moment the international environment

[387] And it may have narrowly avoided the Type II error by assuming Japan was not seeking atomic weapons.

begins to resemble Francis Fukuyama's thesis.[388] Conflict has largely declined in the Northern hemisphere. The IAEA has increased its budget commensurate to the size and scope of its mission and for years has found compliance is the norm. The United Nations has largely turned to humanitarian missions, focusing on women's rights in developing nations, access to potable water and food in areas affected by natural disasters, and developing coed soccer-based missions along historically disputed borders. Next year is the NPT Review Conference, and there is talk that the NAM, led by the Republic of South Sudan since its ascendency to the NPT, is going to push for a universal disarmament treaty.

The P5 objects. Although major international disputes have been resolved, the memory of conflict still lingers. The Outlier States object on different grounds. They view the P5's objection as hypocritical and worry that a disarmament treaty will exempt legal nuclear weapons states, according to the NPT. The Outlier States will not agree to a treaty that punishes them and rewards the major powers. At the NPT states' urging, UN Secretary General Malala Yousafzai calls a session between key stakeholders and introduces a necessary clause that allows current nuclear weapons states and any state currently in possession of nuclear weapons to re-proliferate in the span of six weeks in the event that those individual states' national security needs substantially change. This requires two things: 1) withdraw from the treaty takes effect immediately after announcement, and 2) states are legally permitted to store under safeguard enough special nuclear material and technologies to proliferate within six weeks. After tense negotiating, the P5 agrees to the treaty's terms. The Outlier States agree on condition that they

[388] Fukuyama placed emphasis on liberal and social democracy's victory in the ideological struggle against communism. In a world comprised of democratic states, conflict becomes unnecessary. Because I am interested in studying the problems as they are, I cannot compel democracy into the simulation. Therefore, let us just agree that the decline of disputes has made the world less interesting. See Francis Fukuyama, "The End of History?" *The National Interest*, no. 16 (1989), 3-18.

play a larger role in verification. At the NPT Review Conference the treaty is signed and, over the next year, all existing nuclear weapons, special nuclear materials, and components are dismantled, destroyed, mothballed and/or placed under safeguards. There is now universal adherence to the NPT and Comprehensive Safeguards Agreement with the Additional Protocol.

A few years later Japanese fishermen suffer navigation system failure and head towards the closest land, which is a man-made island presently occupied by the Chinese Navy. The fishermen are accused of being Japanese spies, intent on testing the limits of the maritime treaty in hopes that China will back down and chip away at the treaty. Japan vehemently denies this accusation and calls upon the UN to intervene and return the fishermen to their native lands. Fearing further encroachments in China's territorial waters, China deploys twice as many Naval vessels to police the South China Sea, de facto expanding China's sea claims with a fifty-mile buffer zone. A US-led coalition with Japan and several South East Asian nations deploy forces to counter the new Chinese threat and to protect free navigation as part of the maritime treaty. A few small skirmishes between trawlers and the Chinese Navy ensue, leading to US-led countermeasures. China mobilizes its reserve forces, which sparks worry in India. India deploys standby forces to the border. China, fearful that its national security is at stake, expels IAEA inspectors and threatens to invoke the re-proliferation article of the disarmament treaty.

The US, India, and Russia immediately view this threat as a ploy to become a global military hegemon. Pakistan worries that India will invoke re-proliferation to counter the Chinese threat. The entire world hears the rumblings of WWIII. Satellite images capture US teams funneling resources to its enrichment facilities at Oak Ridge National Laboratory, and the IAEA is concerned that the US will break the tamper-proof inspection seals on canisters containing safeguarded plutonium in New Mexico. Attempting to deter the US from clandestinely

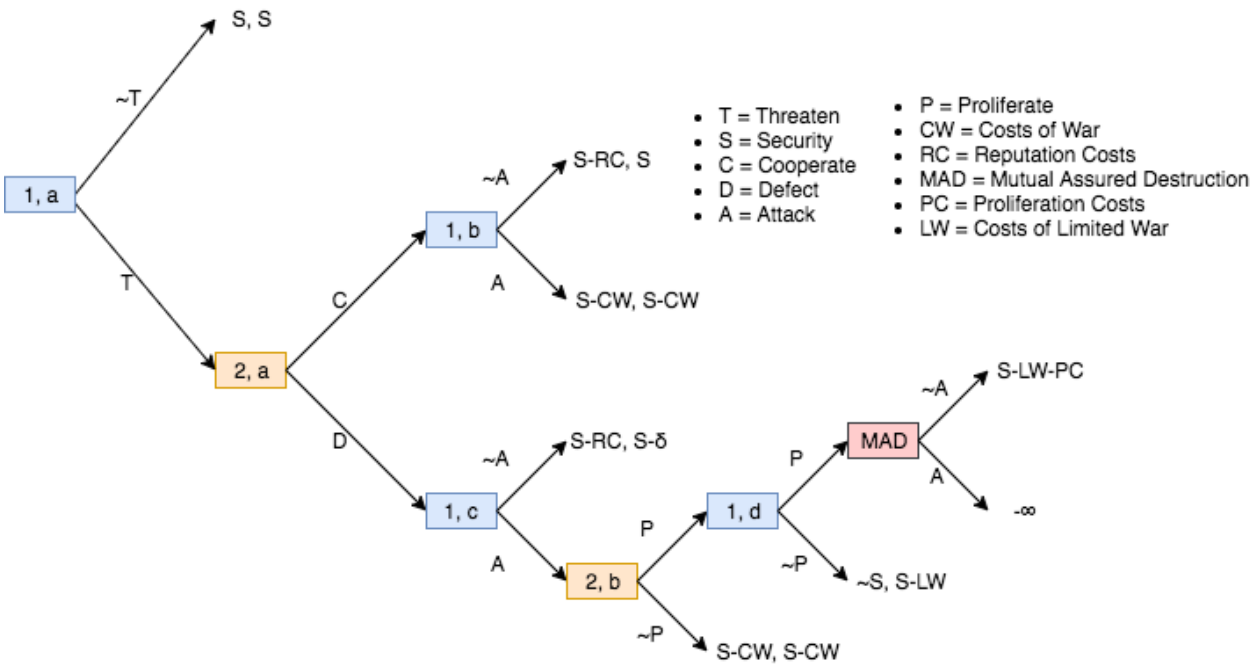
proliferating, an event that could have catastrophic results, the IAEA makes an emergency statement condemning the US's movements. Russia and China read the statement, and, fearful they will be attacked without a nuclear deterrent, invoke the re-proliferation article. Within months nuclear re-proliferation has cascaded through the international system. At least six states now have the ability to inflict a second strike on any aggressor, while England, France, Japan, Saudi Arabia, and Australia reconsider their nuclear options.

We might assume this would demonstrate the infeasibility of universal disarmament. On the contrary, it demonstrates that disarmament is possible when the system demands it. In addition to avoiding WWIII by using nuclear deterrence as a buffer against war, the treaty successfully dismantled all existing nuclear weapons and provided a known pathway towards future disarmament. During the ensuing years while the international community deals with newly emerged disputes that threaten global war, diplomats can once again use preexisting frameworks to address the nuclear weapons problem.

But more important, this escalation of military violence that compelled re-proliferation serves to strengthen my central argument. That is, Perkovich and Acton's *Abolishing Nuclear Weapons* offers some insight. Nuclear deterrence can give way to deterrence through proliferation threats. By offering previously proliferated states the option to proliferate in short order, deterrence of even small wars is maintained because the calculus demands the outcome be identical to MAD.[389] In other words, MAD is replaced with the threat of MAD against states behaving belligerently (*Threaten*). Figure 8.1 highlights this.

[389] Perkovich and Acton, 102.

Figure 8.1: Maintaining MAD without Nuclear Forces: Extended Form Game



This game illustrates how two states in conflict seeking to maximize security can be deterred by the potential threat of MAD, The purpose of this game is for either side to maximize security along the lines of realist schools of thought. Four assumptions are given. First, in the scenario illustrated in Figure 8.1, two former nuclear powers are in a competitive and conflictual relationship. Neither their histories nor their present arrangements leave either side completely trusting of the other. Second, this is not a fictional universe where the knowledge of fission has been erased: nuclear know-how exists. Third, both sides have the ability to produce a second strike capability within a relatively short timeframe (six weeks is sufficient). Fourth, both sides have stated their resolve to resume their nuclear weapons programs if the other side resumes theirs. Finally, if the game progresses to the final stage, where MAD is reestablished, then neither side can move. The payouts for attack under MAD is, as the name implies, assured

destruction. Therefore, MAD is secure, but it is costly, given both sides must resume their weapons programs and engage in counter attacks.

In other words, Figure 8.1 illustrates a scenario where two sides in conflict with nuclear know-how—and with perfect information about the other side[390]—must choose between behaving according to the new status quo—global powers without nuclear forces—and behaving according to the former status quo under MAD.

Player 1's payout are listed first, followed by a comma "," and Player 2's payout, except in the final round along Player 1's "d" move, where both sides receive the same payouts under MAD and are therefore combined into a single payout.

Working backwards with a payout of *MAD*, Player 1, at movement "d," has the option of proliferating and receiving *MAD* (which requires the costs of a limited war *LW* and the costs of proliferation *PC*) and insecurity *~S*. *MAD* is preferable to insecurity. It is also stable, and any preceding war will be limited once nuclear weapons are added, due to the longstanding reasoning that nuclear weapons erase uncertainty of the other's capabilities, thus compelling conflict de-escalation.[391] As previously mentioned, *MAD*'s stability applies an equal payout to both players 1 and 2.[392]

From there, Player 2, at its "b" position, gets to move only if Player 1 has attacked it. Its payouts include proliferating and achieving *MAD* and not proliferating and leaving the resolution

---

[390] Both sides know that the other is capable of proliferating retaliatory nuclear forces within a short timeframe due to carefully scripted arrangements within a disarmament treaty.
[391] Waltz (1981), 7.
[392] Skeptics might charge that if either side proliferates first, the calculus shifts, and the side with nuclear weapons can circumvent MAD with a preemptive strike. This would certainly be a concern if the world looked as it does today; however, in the world I propose, each side's short lead time towards proliferation means simultaneous re-proliferation is likely. Additionally, the fear that one side *might* proliferate first is precisely the reason why this game's equilibrium includes no paths towards either side proliferating first.

of the war up to potential attrition. In other words, its payout is security *S* minus the costs of a limited war *LW* and the costs of proliferation *PC* against inevitable security[393] minus the costs of a total war that is uninhibited by proliferation. Considering it prefers a limited war to a total war, and that proliferation costs are sufficiently low, due to onsite Plutonium reserves and immediate access to mothballed weapons components, Player 2 will choose the route that achieves *MAD*.

At Player 1's "c" position, Player 2 has previously defected *D* from the nonproliferation agreement, prompting Player 1's next movement. Player 1 knows that if it attacks, Player 2 will proliferate, and if Player 2 proliferates, Player 1 must proliferate, or else it risks annihilation. At this stage, if Player 1 does not attack it receives security *S* minus some reputational cost. Player 2 receives security *S* minus some undefined costs δ due to violating international norms relating to decency. The calculus is not perfect here. It is reasonable to assume most states would prefer reputational costs to the costs of limited wars, but this is not always the case. For example, it can be argued Saddam Hussein preferred the costs of a limited war to reputation costs during the 1990 – 1991 Gulf War. Indeed, Baudrillard argues the war was carefully scripted to maximize Iraq's and the coalition force's reputation, while both sides willingly inflicted war costs on Iraq's civilians.[394] Furthermore, reputational costs might also be associated with sanctions or other punishments. Therefore, one can assign some probabilities to this round. It is reasonable to assume Player 1 will choose to back down and not attack with probability *p* and will attack with probability *1-p*. *P* can be set to 0.25 for the sake of illustration, but *p*'s value does not affect the game's ultimate outcome.

[393] Considering future wars are not zero-sum.
[394] Jean Baudrillard, *The Gulf War did not take place* (Sydney: Power Publications, 2018): See esp. Chap. 4.

Considering that Player 2 instead chose to continue to cooperate *C* with the nonproliferation agreement, Player 1, at its position "b" must choose between attacking Player 2, despite Player 2's continued nuclear cooperation, and receive eventual security *S* minus the costs of total war *CW* and receiving security *S* minus some reputational costs *RC* due to its belligerent actions taken at its position "a."

At Player 2's position "a," Player 1 has violated international standards of decency by threatening its former nuclear neighbor. Player 2 must choose between continued cooperation *C* and defection from the nonproliferation agreement *D*. If it chooses *D* it knows it is setting in motion a cascade of events that will culminate in *MAD*. On the other hand, if it chooses *C*, it has some probability of achieving and maintaining a payout of security *S* based on Player 1's preferences between reputational costs *RC* and the costs of a total war *CW*. Therefore, this game cannot determine with certainty Player 2's movement at its position "a."

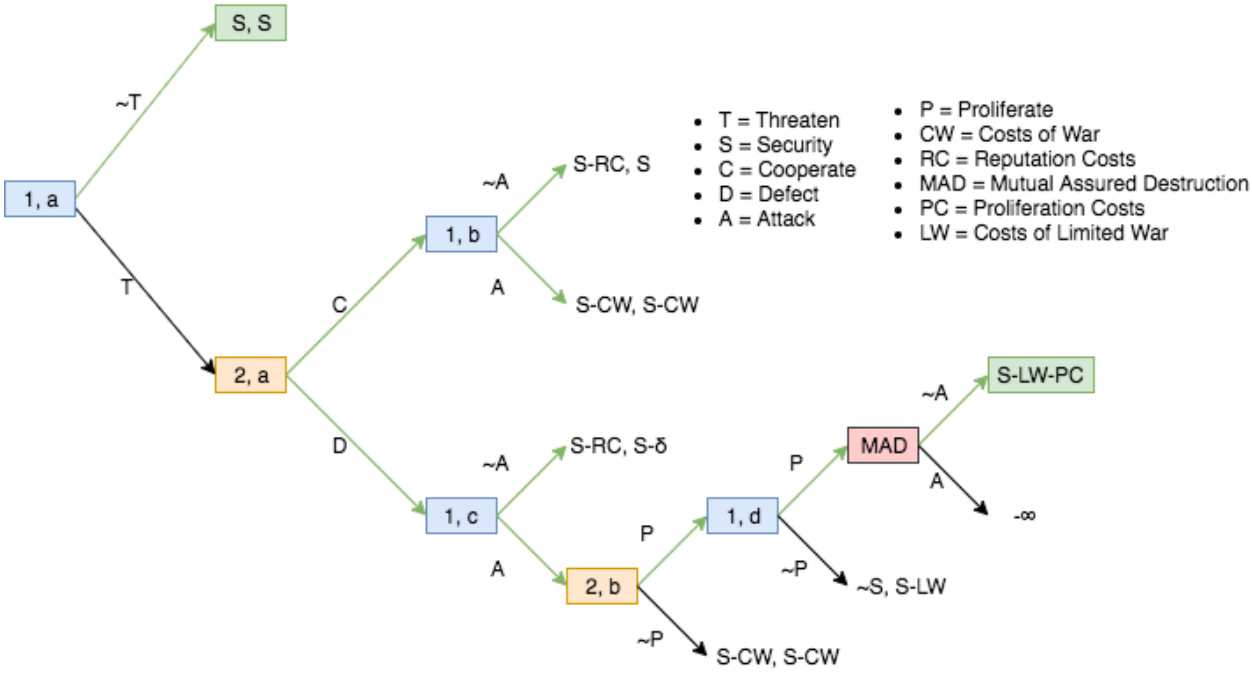
Finally, at Player 1's position "a," it can continue to be in good standing with the nonproliferation agreement and refrain from threatening behaviors ~*T* or it can threaten its former nuclear neighbor *T*. An example might be a maritime power asserting dominance over shipping lanes previously agreed to be international waters. If it plays *T*, it knows it will lose something. It will eventually achieve security, but will suffer some costs. It would be a limited or total war, there could be reputational costs, and there could be the additional costs of proliferation. Otherwise, Player 1 can play *T* and continue to enjoy security *S* without any additional costs.

In order for this game to be accurate, any disarmament accord and nonproliferation treaty must make certain steps immediate, and they must have high probabilities of detecting clandestine defection. This includes IAEA monitored cameras in plutonium and uranium storage

areas and electronically monitored seals that can alarm if tampered with. Additionally, it might require IAEA inspectors under diplomatic privilege live in country so that they can visit and inspect any anomalies within twenty-four hours. Without these provisions, clandestine defection might be preferable, rendering the game irrelevant.

Figure 8.2 illustrates how this game is solved. The unbroken green line from the first round to a final payout is the desired path.

Figure 8.2: Maintaining MAD without Nuclear Forces: Solved



This game's outcome suggests the logic set forth by Perkovich and Acton; in a world where nuclear weapons have been abolished, maintaining the relatively peaceful nuclear-free world requires an understanding of Mutual Assured Proliferation, as negotiated in a future disarmament treaty, as a means for reestablishing MAD. That is, simply threatening a belligerent actor with proliferating can maintain relatively peaceful relations between nations. And because

the cost of proliferating is MAD, and because MAD is costlier than the status quo, proliferation contradicts each side's preference to maximize its utility. The costs of proliferation are high and the benefits are zero if one cannot use the weapons they proliferate. In short, Mutual Assured Proliferation in a disarmed world can be as effective as MAD was during the Cold War.

8.4 Dealing with the Remaining Uncertainties

This final substantive section identifies three remaining major areas of concern pertaining to the model developed in earlier chapters. First, Outlier States remain a foremost area of worry, particularly because recent history has not treated many Outlier States well. Second, there is a reasonable assumption that not all negotiations will occur in good faith. Some stakeholders, particularly individual states, might misrepresent their preferences in order to avoid a worst-case scenario outcome. Finally, the model's data is user defined along a Likert-type scale. This presents several points culpable to flaw during the "knowledge capture" phase of modeling. These uncertainties demonstrate a need to tread lightly when attempting to negotiate to global zero.

Outlier States

IAEA safeguards failed twice in Iraq. Prior to the Persian Gulf War, the IAEA and the international community incorrectly believed Iraq was in compliance with the IAEA and the NPT (a Type II error). Although Iraq was party to the NPT and the IAEA, it secretly funded a nuclear weapons program without the IAEA's or the international community's notice. Following the 1991 war, the IAEA discovered Iraq's burgeoning militarized nuclear program, which included enough nuclear material to build a weapon (although many technical hurdles still

existed). After this discovery, the international community held Iraq to higher scrutiny. Saddam Hussein, however, slowly decreased IAEA inspectors' access to facilities under safeguard, culminating in Iraq's complete refusal to allow inspections. US President George W. Bush viewed Saddam's refusal as a tacit acknowledgement that Iraq had resumed its weapons of mass destruction programs. In February 2003, shortly before the war, Saddam sat down for an interview with Dan Rather, an American news anchor for *CBS Evening News*. Among other things, Saddam insisted Iraq was not manufacturing or in possession of weapons of mass destruction. He also insisted he would not step down. After this interview aired, Bush decided to invade Iraq and force a regime change. Following the 2003 invasion of Iraq, the IAEA and other inspectors found no evidence of Iraqi weapons of mass destruction programs (in other words, they committed a Type I error). Saddam fled, was captured several months later by US forces, stood trial for war crimes, was convicted, sentenced to death, and subsequently handed over to Iraqi officials a few months shy of his seventieth birthday. Had the US forces held onto Saddam until he reached seventy, he would have been ineligible for capital punishment under Iraqi law. Saddam was executed by year's end.

Saddam's ouster over its WMD program signaled to Libyan leader, Muammar Gaddafi, the extent to which the US was prepared to curb nuclear proliferation. Libya had a long-standing desire to proliferate, although its attempts to build weapon components, enrich uranium, or purchase weapons on the black market were usually unsuccessful. But following the US's response in Iraq, Gaddafi changed course. He sought to work with Bush, the IAEA, and international organizations in exchange for sanction relief. The disarmament of Libya was a strong success, and Gaddafi spent the next decade increasing his international image as Chairperson of the African Union. By early 2011, however, the Arab Spring had broken out, and

Gaddafi's Libyan regime swiftly faced a civil war. US President Barack Obama and NATO backed the Libyan rebels, viewing this as an opportunity for regime change in Libya. NATO forces attacked Gaddafi's convoy in October 2011. The leader was quickly captured and assassinated.

Following a lengthy war with Iraq, the Islamic Republic of Iran sought to acquire a nuclear deterrence. Being a revolutionary government founded upon the overthrow of a Western-backed monarchy, Iran inherited many of the tools necessary for uranium enrichment. For the next three decades—during which time Israeli strikes, cyber-attacks, and international sanctions were imposed—the international community viewed Iranian proliferation as an immediate area of concern. By 2005 the nuclear standoff reached its apex when Iranian President Mahmoud Ahmadinejad removed monitoring devices the IAEA had installed on materials placed under safeguard. For the next decade the international community and the IAEA engaged Iran with sanctions and diplomacy in hopes of bringing Iran back into good standing with the IAEA and the NPT. The results of years of maneuvering was the 2015 Joint Comprehensive Plan of Action, which eased Iran's sanctions in exchange for robust nuclear safeguards that effectively stopped Iran from proliferating in the short- to mid-term. The agreement was signed by leaders from the P5, Germany, the European Union, and Iran. While this agreement demonstrated that nuclear nonproliferation was still viable as a product of diplomacy, the agreement's future is uncertain. At the time of this writing (January 2019), the US, under President Donald Trump, is no longer party to the plan and has announced its blueprint for re-imposing Iranian sanctions.

These developments highlight the effects of uncertainty and the need to understand that states might be apprehensive to engage with the major powers out of fear of being punished. Saddam Hussein was executed. NATO attacked Muammar Gaddafi, which led to his

assassination. The US sanctioned Iran. All of these developments occurred despite these leaders and countries changing course and abandoning nuclear weapons programs.[395] Therefore, it is reasonable that Outlier States might approach negotiations with trepidation, particularly the DPRK.

Recalling Richardson's arms race model, where a state's military spending is a function of its adversary's military spending, we can see that modeling human behavior is far from perfect. Richardson himself acknowledges this limitation, writing, "Such a psychological effect [holding a grievance] cannot be properly described by linear equations."[396] In other words, it is necessary that we understand the history between the two nations that led to hostilities, especially because nations might not balance against their adversaries. In this model, understanding international history, particularly what happened to leaders who abandoned their programs and paid the ultimate price anyway, takes place outside of modeling, but is essential to the success of a nuclear disarmament treaty. Would Kim Jong Un agree to total nuclear disarmament and strict IAEA jurisdiction if doing so would remove all deterrent from NATO strikes designed to help overthrow the Kim Dynasty? Would Pakistan trust that Western allies would protect Pakistani leaders during civil unrest if there are no nuclear weapons to keep out of the hands of non-state actors?

There is some hope for the DPRK and Pakistan. The India-Nuclear Suppliers Group agreement between India and the US under George W. Bush contradicts US activities against Iraq, Iran, and Libya. India was rewarded with increased access to the nuclear energy market, despite India being a non-recognized nuclear weapons state. And given that it cannot be guaranteed that components sold to India will not be used in its weapons program, the Bush deal

[395] In Iraq's case, Saddam was playing by the rules, but he appeared to be breaking them.
[396] Richardson (1993), 268.

could be in violation of NPT Article I, which prohibits states from assisting states in their nuclear weapons programs. In other words, there is no necessary cause and effect between proliferation or nonproliferation actions and reward or punishment.

Furthermore, this model does not reflect other wants, goals, or capabilities not explicitly part of the problem. Outlier States seek prestige in this model, but they also have other interests, both domestic and abroad. These apply to all states and include internal stability, access to international markets, alliances with friendly neighbors against neighborhood threats, and others. Non-state actors have other interests as well, including prosperity, security against disease, and access to potable water and food, etc. While these interests do not have a substantial effect on decisions to proliferate or disarm, the impact is not zero.

These uncertainties, however, which exist even in the presence of binding international law, do not offer the model's results considerable strength. I *would* recommend that states tread lightly when negotiating a future global disarmament treaty, but the Outlier States will already be highly skeptical, at best.

Good Faith Goals and Negotiations

Brazil's proposed late 2020s nuclear-powered submarine, the French-designed SN *Álvaro Alberto*, presents a unique conundrum for future nuclear safeguards negotiations. IAEA safeguards agreements and the NPT were negotiated at a point in time when nuclear weapons already existed, and the nuclear haves were not ready yet to become nuclear have nots. Therefore, exempt from IAEA safeguards inspections are nuclear technologies for military purposes. The logic of these agreements is straightforward along two lines: First, the recognized nuclear weapons states already have nuclear weapons and therefore do not need to divert

materials to clandestine nuclear weapons programs. Inspections would be a waste of energy and resources. Second, inspections of military capabilities risks the inspected state being forced to divulge secret military information to the international community, a violation of state sovereignty. Therefore, at the time it was reasonable to include provision prohibiting the inspection of militarized nuclear technologies. Furthermore, at the time of negotiation, nuclear have nots were more interested in securing their current and future rights to nuclear energy for civil purposes, rather than nuclear energy for military purposes. The problem facing the IAEA at the present is that Brazil has a right to nuclear submarines, and once it secures a nuclear submarine (which carries with it a reactor capable of producing plutonium), the IAEA will be all but powerless to prevent Brazil from proliferating.[397]

The scenario above illustrates conflicting goals. On the one hand, some states desire nuclear propulsion for their navies; on the other hand, many states, as active members within the IAEA, want to safeguard all points along the nuclear fuel cycle to prevent proliferation. These are not the only conflicting goals. Some states (namely New Zealand) presently take the position that even nuclear power is dangerous.[398] In other words, there are several competing goals, and synthesis between them falls under the domain of social choice theory or collective choice theory. This is also certainly true for the problems defined in earlier chapters.

---

[397] The IAEA is not completely powerless because, as Costa points out, safeguards agreements for military equipment cover nuclear material presently being used for military purposes. Spent fuel will fall under safeguards once removed from the submarine. See Eugenio Pacelli Lazzarotti Diniz Costa, "Brazil's Nuclear Submarine: A Broader Approach to Safeguards Issues," *Revista Brasileira De Política Internacional* 60, no. 2 (2017): e005.

[398] The discussion on global warming has begun to shift this position. See "Nuclear Energy Prospects in New Zealand," *World Nuclear Association*, last modified April 2017, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/new-zealand.aspx.

In a non-dictatorial international community, where future nuclear weapons states negotiate under the assumption that a disarmament treaty is binding, the logic of realism is not displaced. Rather, given competing goals and the ability to cast a (very weighty) vote, nuclear weapons states can partake in strategic voting, where it changes its preferences in order to secure a non-worst-case-scenario election outcome.

The concept of strategic voting was first independently formulated by Gibbard in 1973[399] and Satterthwaite in 1975.[400] The Gibbard-Satterthwaite theorem holds that in an election that is non-dictatorial and has non-limited alternatives, possible outcomes are susceptible to strategic voting. Using Brazil and the nuclear submarine as an illustration, strategic voting might occur when the IAEA brings Brazil to the negotiating table as the late 2020s launch date approaches. The future Brazil might prefer to maintain the same level of sovereignty over its military forces as the P5 (we will call this *A*). In other words, its submarine is off limits to inspectors, during fueling, operation, and refueling, and at no point during the nuclear fuel cycle are inspectors allowed. Its second preferred state might be to remain in good standing with the IAEA and the international community to avoid costly sanctions (*B*). Its least preferred state might be to incur sanctions costs (*C*).

Therefore, Brazil's preferences are

$$A > B > C$$

[399] Allan Gibbard, "Manipulation of voting schemes: A general result," *Econometrica* 41, no. 4 (1973): 587-601.
[400] Mark Allen Satterthwaite, "Strategy-proofness and Arrow's conditions: Existence and correspondence theorems for voting procedures and social welfare functions," *Journal of Economic Theory* 10, no. 2 (1975): 187-217.

And assuming there are several other voters, it might be the case that many future states are members of Nuclear Free Zones and therefore take the New Zealand position and strongly support sanctions for states that violate the taboo against nuclear propulsion. That is, they strongly prefer *C* to *B* or *A*. A considerable chunk of the international community supports strengthening the IAEA's ability to conduct inspections while ensuring NPT states' right to nuclear technology. That is, they prefer *B* over *A* or *C*. Facing the threat of sanctions, Brazil might change its vote from *A* to *B*. In other words, this hypothetical future Brazil has engaged in strategic voting in order to prevent the worst outcome.

Strategic voting might also mar a FCM's outcome, particularly if one expands the P5 and Outlier States into individual stakeholders. In a model where the US and the DPRK are negotiating the DPRK's nuclear disarmament, it is reasonable to question whether or not, for example, US President Donald Trump and DPRK Supreme Leader Kim Jong Un are negotiating in good faith or whether or not either or both of them are misrepresenting the order of their preferences in order to attain a better outcome.

Taking this into a larger context (the "mess"), uncertainties grow. Future practitioners and modelers should be aware of these uncertainties and work on ways to mitigate them. While uncertainty can never be eliminated, understanding that uncertainty exists can help satisfy Sterman's requirement for a more "useful" model.[401]

Knowledge Capture

Despite Outlier State involvement and overcoming strategic voting, useful models need to accurately represent the world in which they are operating. The model shown in the preceding

[401] Sterman, 90.

chapters contains 55 components with 166 non-zero links between them.[402] If one includes the zero (or non-links), the number of possible combinations is quite large. This leaves nontrivial space for modeler error. Indeed, using the sigmoid transfer function and not limiting it with a Likert-type scale, the number of possible variable value combinations reaches infinity.

In a perfect world this study would have been created with input from government leaders, particularly the P5, the International Atomic Energy Agency, non-governmental organizations, and other relevant stakeholders. This is not a perfect world, however, and there are major limitations to my ability to secure meetings with leaders like Kim Jong Un. These limitations have the potential to translate directly into the study. Therefore they must be addressed.

Jetter and Kok identify three sources for knowledge: the modeler, documents, and expert survey. This study relied on the first two solely without expert input. Certainly, expert involvement would increase the model's fidelity, but its contribution at this phase—when the international community has not yet resolved major international disputes—is not likely to change much of the model's performance.

Due to the application of the Likert-type scale, variation is subjectively defined. This limits potential inaccuracies and increases robustness when real-world scenarios change by small amounts. For example, as the model stands, the IAEA can moderately increase nuclear weapons states security. If the IAEA increases its budget by 10%, this needn't translate into a precise value; rather, the Likert-type scale might still define its ability to increase security as moderate.

Therefore, while future models, particularly those used in practice rather than study, will benefit from increased participation of experts, especially if these experts are relevant

[402] Accurately defining no relationship between components is just as important as accurately defining a relationship. Refer back to the discussion on the Type I and Type II errors.

stakeholders. For the purpose of an exploratory study, however, it is reasonable that experts are not necessary at this time.

8.5 Summary

The preceding chapters carefully build a model of the nuclear weapons "mess" and its constituent problems. This chapter attempts to acknowledge areas of remaining concern and to address possible ways to mitigate some of this concern. It cannot be stressed strongly enough, however, that future leaders should approach global disarmament negotiations according to the realists before them: With a strong dose of skepticism. But this does not mean future negotiations are futile.

The threat of war can be moderated. Leaders most likely will not be able to even have disarmament talks if there are remaining major international debates, such as the South China Sea and Crimea. While it is not impossible for these international problems to flare up again following successful disarmament talks, especially if Graham Allison's *Thucydides Trap* accurately points to pattern, it is also likely that successful disarmament talks would be the resultant and perhaps necessary conclusion of successful resolution of areas of global concern. Additionally, disarmament in the twenty-first (or beyond) century is not to harken back to a time before fission was discovered. A disarmed world cannot appear unrecognizable; therefore, former nuclear weapons states, either by design or by default, will have the capability of re-proliferating and reviving their second-strike capabilities in a matter of weeks. These capabilities, instead of making a disarmed world less likely, will benefit the disarmed world by maintaining MAD with a small tweak; MAD will be amended with the threat of MAD, or mutual

assured proliferation, which must result in the revival of MAD. In other words, the disarmed world is not as uncertain as realists might assume.

Finally, there are less major (but not minor) uncertainties still remaining. Outlier States have no guarantees, especially if history is a good indicator, that they will not be punished after dismantling their nuclear weapons programs. Western states have a growing history of supporting regime change in states that have changed course from rogue to team player. Therefore, Outlier States with current or burgeoning nuclear deterrents will understandably approach disarmament negotiations with healthy levels of suspicion. On the other hand, there is no discernable cause and effect; other Outlier States have been rewarded by the international community, despite having gone rogue. Finding the cause behind the reward might allay Outlier States' distrust.

CHAPTER 9

DISCUSSION AND CONCLUSION

9.1 We Cannot Get to Disarmament Now

The preceding chapters highlight an obvious truth; disarmament is not a feasible outcome in the present, despite what the simulation suggests. This study opens with an undeniable fact that I do not intend to conceal. There exist too many ongoing geopolitical disputes to undermine the realist position on nuclear weapons. Namely, while realism cannot explain the lack of horizontal nuclear proliferation, it explains perfectly why nuclear weapons states fail to live up to their expectations in the NPT Article VI. To do so would, for example, substantially lessen the power gap between the US and China in the South China Sea and remove most disincentives for war. The ultimate Type IV error in global disarmament is World War III and a resultant race towards rearmament, an outcome that does not preclude the possibility of a nuclear war. The first side to rearm would require a demonstration of their nuclear deterrent, and they might be persuaded to attempt to destroy another side's nuclear facilities to prevent it from gaining its own deterrent. This study does not attempt to ignore reality or place the reader in another universe, and therefore it accepts that disarmament is neither easy nor likely in the short term.

On the other hand, recent history has witnessed the elimination of Libya's nuclear program (2003), the Joint Comprehensive Plan of Action that abolished Iran's nuclear program (2015), and, most notably, the DPRK-ROK-US ongoing peace and disarmament talks (beginning in 2018). These demonstrate that significant progress can be and is being made. Therefore, the abolitionist must not worry that global zero is perpetually out of reach, as my study reveals. But the abolitionist would be wise to refrain from pushing too hard now; doing so might convince

nuclear weapons states to withdraw from treaties they feel undermine their national interest, pushing global zero further into the future, a Type IV error.

But the realism in international relations scholarship that holds us to our nuclear arsenals also faces anomalies from within. On the one hand, we have the Waltzes and Mearsheimers who claim that simple cost-benefit calculations under the perfect certainty nuclear weapons provide make it not just rational for states to possess nuclear weapons; they strongly imply or explicitly state that possessing nuclear weapons is the preferred state, even when speaking in terms of our foes. On the other hand we have the Sagans and Booths who accept the balance of power and anarchy as dominant ordering mechanisms, but reach a radically different conclusion, despite working with the same bank of evidence.[403] They argue it might actually be preferable to rid the world of nuclear weapons and that this conclusion can be reached without violating the basic tenets of political realism.

Chapter 2 highlights this study's urgency. Although the risk of nuclear war is low, following realist logic, the costs of even a small nuclear war are sufficiently high to warrant a sincere discussion about the role nuclear weapons play in international affairs. These costs include not only the loss of human life, but major psychological, economic, and social stresses that play against global meteorological consequences, reducing resources and leading to chaos in some regions. Additionally, the simple fact that *capability* matters more than *intent* requires that we accept that any country with nuclear weapons has the *capability* to use them, despite their *intent* to deter and be deterred. The fact that nuclear deterrence can break down, and the fact that a resultant nuclear war—whether limited or total—would be catastrophic, including the

[403] Sagan notes that states are likely to make both the Type I and Type II errors when comparing their neighbors' capabilities to their own, and that these errors increase the likelihood of nuclear conflict. Sagan and Waltz, 115-116.

possibility of the human extinction, means it is, for many, a moral obligation to work towards nuclear abolition. For others, it might be simply a different calculation of survival dressed up as morality. It is rational to take action that prevents the human extinction.

Jonathan Schell, in his 1984 essay, "The Abolition," stumbled upon an alternate structure to realism, seemingly by accident. He notes that human beings tend to be altruistic, willing to contradict the very sanctity of their mortality. Every now and then, an individual is called upon to lay down his or her life in exchange for the well being of a loved one or a community. And often this individual answers that call. These are not people suffering from depression or other risks associated with suicide. Often these are parents sacrificing their lives to save their children. The child's future is worth more than the parent's future to the community. Indeed, their communities often shame parents that eschew this moral obligation. Schell carries this to a likely conclusion in nuclear affairs. If we are able to rationally sacrifice our lives for a single other person, and because a major nuclear war means likely extinction, which means the death of the individual for whom we are ready to sacrifice our lives, then we can rationally seek the abolition of nuclear weapons—to prevent extinction and save lives.[404] Indeed, the abolition of nuclear weapons is the only cause that can necessarily prevent human extinction. Altruism means abolition, otherwise our altruistic sacrifice is meaningless.

In this sense, realist authors face a serious external challenge to overcome. Do emotions such as love matter? Is love a guiding force—a structure in the system of human behavior? Does love overcome the cost of death? Human beings are altruistic, but is altruism a choice or a necessary conclusion? If altruism is a choice, then realism tells us altruistic suicide is irrational. Émile Durkheim struggled with this in the nineteenth century, ultimately contradicting realist

[404] Schell, 4.

rationalism, arguing that, "Now, when a person [commits altruistic suicide], in all these cases, it is not because he assumes the right to do so but, on the contrary, *because it is his duty*. If he fails in this obligation, he is dishonored and also punished..."[405] If duty is a structural force, then realism needs to account for it. Altruistic suicide is also not as rare as one might imagine. The US Congress often awards its highest military award, the Medal of Honor, posthumously to military personnel who deliberately end their own lives to save their fellow soldiers. Durkheim also implies that spending one's life being labeled a coward is worse than death. Therefore, at the very least, it is possible realist logic has miscalculated human preferences.

Altruistic suicide means that human beings are not *necessarily* calculating to maximize their power in an environment where there is no acceptable alternative to survival; as individuals we are willing to accept death under certain conditions, and according to Durkheim, death under these conditions is rational and preferable to one or more alternatives. In other words, there are at least two non-mutually exclusive alternatives to Waltzian realism if individual behavior translates to international decision-making: our desire to see our loves ones survive, even at our own expense, and the fear of dishonoring our communities and failing to live up to their expectations. These two alternative considerations do not attempt to erase realist considerations. The balance of power in international relations still dominates our ways of thinking, but it is not the only thing we think about. And overcoming the balance of power is not outside the realm of possibilities or observed human behavior.

Schell argues our morality is a viable alternative to the balance of power because, as I demonstrate in Chapter 2, law does not bind deterrence. The failure of deterrence necessitates a

[405] Émile Durkheim, *Suicide: A Study in Sociology* (Glencoe, IL: The Free Press, 1951), 219.

"moral deterrence" that guides our behaviors, despite the consideration for our foes' capabilities.[406]

Schell is aware of longstanding realist tradition governing nuclear weapons. He is under no illusion that utopia is simpler than deterrence. But he likens the moral obligation towards abolition to an awakening. Slavery, he writes, once a normal US institution, is now considered abhorrent following a global awakening against it.[407] Wartime rape, gladiator death matches, torture, and pistol duels all met similar fates to social awakenings (more or less), what Wheeler and Booth might call "confronting the unthinkable."[408] And if we accept that each of these former institutions benefitted human beings in some way, thus helping to maximize utility for someone at some particular point in time, then we can make a reasonable hypothesis about torture, for example. We can reasonably hypothesize that torture existed on a massive scale simply because people received benefit from torturing people. If this is true, we can also reasonably hypothesize that states resist efforts at nuclear abolition merely because at some level those states benefit from possessing and possibly using nuclear weapons.[409] But this benefit can be erased not merely through deterrence breakdown, but also by a social awakening. This elementary argument basically follows lines of thought offered by social constructivists. In other words, states have nuclear weapons simply because it is normal to have them. Their value is constructed before, after, or both before and after they are proliferated and by the possessor and

---

[406] Schell, 6.
[407] Schell, 8-9.
[408] The overnight German reunification was "unthinkable" until it happened. This compels us to consider that the "unthinkable" is not impossible. Wheeler and Booth, 24.
[409] Press, Sagan, and Valentino argue Americans, for example, are only averse to launching costly first strikes, but if the risk of retaliation is low enough, Americans support first strike/first use. That is, under certain circumstances, Americans benefit from using nuclear weapons. Press, Sagan, and Valentino, 188.

the rest simultaneously.[410] In short, nuclear weapons have meaning because we give them meaning. Constructivist reasoning does not deny the balance of power; it only challenges the idea that it is structured into the international system. Human beings, contrary to Waltz, have agency and free will insofar as they can choose to balance or not. Altruistic suicide, therefore, appears both a duty and a choice.

Therefore, while we are stuck with nuclear weapons in the present, it is not unthinkable that states will be willing to give up nuclear weapons in the future. As argued in Chapter 2, this process will likely be greatly accelerated if deterrence ever fails. The survivors of nuclear war will likely take disarmament efforts very seriously in order to avoid a recurrence of nuclear war. They will have a moral-realist obligation to disarm—moral to protect society and realist as a result of calculations that maximize the likelihood of survival. On the other hand, we do not need to suffer a nuclear holocaust. If we accept that the costs of nuclear war will be sufficiently high that our preferences will change in the event of nuclear war, then we can begin thinking about our preferences now while we work diligently towards resolving the half dozen or so ongoing international geopolitical disputes identified by O'Hanlon that inhibit disarmament. My model demonstrates that this is ultimately feasible in the long-term.

9.2 How Can We Get to Disarmament?

The model I construct concludes that future disarmament is feasible, given three steps are taken during disarmament negotiations: first, a global disarmament agreement must not

---

[410] For example, consider Alexander Wendt's reminder that "500 British nuclear weapons are less threatening to the United States than 5 North Korean nuclear weapons, because the British are friends of the United States and the North Koreans are not…" If the situation reverses itself, so too will the US's view of North Korea and Britain. Alexander Wendt, "Constructing International Politics," *International Security* 20, no. 1 (1995): 73.

unreasonably affect states' sovereign rights outside of the agreement; second, states outlying the NPT must be brought into the negotiations (as well as being made to feel as a part of the international community instead of as "rogue" or "hermit" states); and third, present states with nuclear arsenals adopt the IAEA's Comprehensive Safeguards Agreement with the Additional Protocol as a measure of good faith. Additionally, states' rights to the technology inevitably means states should have an ability to re-proliferate in the event of future international instability that threatens global security.

But up until now I have deliberately avoided ongoing international geopolitical disputes that stop the disarmament process dead in its tracks.[411] This gives this study an unfair advantage. It creates a tautology underneath the highly complex workings of the nuclear "mess": *If we make it easy to disarm, it will be easy to disarm*. I would like to bring this study back down to earth and offer insight into ways it is possible to *get to* the disarmament process, rather than simply *beginning at* the disarmament process. But first I'd like to point out that the tautology is not a fairy tale. A footnote in Chapter 7 discusses reductions in major South African security concerns that made the post-Apartheid state's disarmament possible. Reducing realist security concerns are key, a starting point, and not necessarily a circular argument.

The disputes O'Hanlon identifies include international disputes around Eastern Europe, the South China Sea, Kashmir, Taiwan, the Middle East, and Korea. Solving the first three is necessary, and solving the last three is helpful. These are the six geopolitical disputes that hinder or completely prevent efforts towards global zero.

If Chapters 3 – 7 are good indicators, then a good candidate for conflict resolution is fuzzy cognitive mapping using input from living stakeholders. If our goal is to satisfy the realist,

[411] The DPRK in 2018 notwithstanding.

then this method should suffice. Realism suggests states are cost-benefit calculators. If option A benefits the state while option B imposes costs on the state, then the state will always choose option A. If we accept that the realist constantly wants to upgrade its position (or at the very least not downgrade it), and if, as I've demonstrated, fuzzy cognitive mapping is a good way to determine paths towards mutual upgrade, then the realist will often be satisfied with the outcome.

The Fundamental Objectives Hierarchy might be of use, as it updates stakeholder goals. In Problem 1 I updated nuclear weapons states' goals from simply possessing nuclear weapons to maximizing security. If one applies this approach to Russia and Eastern Europe, one can say the same. Russia's attempted territorial annexation of part of Georgia (2008) and its actual territorial annexation of part of Ukraine (2014) is an example of security maximization. This follows realist thinking. Russia's goal was not simply to gain land; the gaining of land served a security need. Once we identify what Russia's actual goal is, then we can begin to talk about alternative ways that maximize security without annexing territory. By taking seriously Russia's actual needs, the international community can find ways to accommodate it in a mutually beneficial way. We can apply this method to the other five disputes.

On the other hand, the 2019 geopolitical climate might make nuclear weapons states skeptical. While conflict resolution might make China gain, China might fear gaining less than it would have if it did not engage in dispute resolution or if it believed it was being required to resolve a dispute the wrong way. Therefore, the relevant stakeholders (i.e., the states) must be enticed by the high probability that their interest will be maximized.

Additionally, steps towards disarmament are usually thought to include negotiated arms reductions or adherence to various test ban treaties; however, the geopolitical concerns above demonstrate the robustness of realist theory. US and Russian non-compliance with parts of the

Intermediate-Range Nuclear Forces Treaty and the subsequent February 2019 bilateral US-Russian suspension of the treaty is a direct result of these ongoing disputes. Russian missile testing and US missile defense systems in Europe, while on paper for national defense, are certainly offense-capable, and the US withdrawal allows it to balance against Chinese missile systems, a *very* realist move.

But this helps to bolster the argument. Because the geopolitical disputes are at least partly about nuclear problems, solving them requires taking steps towards disarmament. This does not dismiss the fact that geopolitical concerns obstruct the signing of the CTBT and help facilitate cheating on and the undoing of the INF Treaty. That is, cause and effect go both directions. In order to stop the cycle, work towards resolution should also go both directions.

What this study illuminates, however, is how many variables are involved in international political problems and "messes." This study identifies 55 nodes with 166 non-zero links between two nuclear problems, and it acknowledges in Chapter 8 that the possible number of links (including zero links) is very large.[412] Therefore, getting to global zero is far more of a complex issue than abolitionists assume. Although after disarmament, former nuclear weapons states achieve quick maximized security, due to the other sides not having nuclear capability, and although this study ultimately concludes with maximized security without nuclear weapons, the simulation revealed a "security period of vulnerability" (Figure 7.5), where the drop in military capability, the buildup of conventional forces, and new strategic posturing to maximize security leads to a security dilemma where the former nuclear powers are worse off than they were prior to disarmament. This "security period of vulnerability" is ultimately overcome, due to increased conventional military spending, increased adherence to international norms, more conformity

[412] Admittedly, some nodes and links are significantly more meaningful than others.

between the major powers, and maximized verification by the IAEA, but the risk of defection or war is remarkably high during the vulnerable period.

This study also reveals that the international system is far more complex than the realist assumes. It is complex enough that states can gain *more* security by multilaterally eliminating nuclear weapons than by keeping them, particularly if one considers the reality that deterrence is not a foregone conclusion. This is because realists assume a lot of things simply do not matter. This model explicitly demonstrates that this assumption is incorrect. Realism can recover if it accepts that it can maximize its security with international components it previously assumed were irrelevant.

In short, it is possible to get to a disarmament treaty. Even though we are not there yet, global zero might be just beyond the horizon, and, indeed, global zero does not belie realism because, as my model shows, it is possible to maximize security more without nuclear weapons.

9.3 Disarmament and the Milieu

A major question remaining is: *What does this study inform?* The results of the simulation suggest that realist states can achieve more through interacting with the social environment, rather than merely focusing inward at their own possession goals. The simulation shows not only maximized security along realist lines, it also shows that by participating in the disarmament negotiations and subsequent treaty, and despite increased conventional military spending, former nuclear powers have avoided the security dilemma, thereby collapsing Lewis F. Richardson's arms race model. But also multilateral self-restraint increases, human rights violations decrease, international transparency increases, states begin to conform, the values we place on international agreements increases, agreement on behavioral norms converges, and

uncertainty decreases tremendously. None of these are possession goals; rather states still seek these goals, even if it means giving up something, because these goals increase states' abilities to shape the social context of their environment. Being transparent, while a concession to the state opening their doors to international inspectors, fosters increased transparency. Being transparent, therefore, shapes the environment and serves as a model of acceptable behavior. These social goals do not necessarily undermine realism; seeking social goals serves the self-interest of the state.

Arnold Wolfers is sympathetic to the realist. He acknowledges that states "place exceedingly high value on the so-called possessions of the nation—above all, on national survival, national independence, and territorial integrity—and to react in fear against any threats to these possessions."[413] That is, states seek to increase their national interest because doing so increases their chances of survival in an anarchical environment. But he also notes that states can increase this national interest in another way—by interacting in social contexts. He writes, "actors can be said to act under external compulsion rather than in accordance with their preferences."[414] South Africa's decision to unilaterally disarm in 1989 illustrates this compulsion to act according to the environment to serve self-interests. Seeing nuclear weapons as merely possession goals would mean South Africa would maximize its deterrence, but other goals served its self-interest, and these goals were external in nature. South Africa desired to re-enter the international community, gain access to international markets, and to, perhaps, remove incentives for the newly formed Namibia to seek a nuclear deterrence of its own. By acting unilaterally against its self-interests, South Africa increased its prestige in the social environment

[413] Wolfers, 12.
[414] Wolfers, 13.

in which it found itself. Further, it was able to influence the environment to reward the post-Apartheid state by seeking this milieu goal.

Wolfers, therefore, goes beyond the basic assumptions of realism, turning realism on its head. Yes, states are cost-benefit calculators, but these states are not merely comparing its power to its neighbors; it is also interacting with the social context, shaping it, influencing the way in which states behave. Wolfers identifies these goals, writing,

> One can distinguish goals pertaining, respectively, to national possession and to shape the environment in which the nation operates. I call the former "possession goals," the latter "milieu goals." In directing its foreign policy toward the attainment of its possession goals, a nation is aiming at the enhancement or the preservation of one or more of the things to which it attaches value. […]
>
> Milieu goals are of a different character. Nations pursuing them are out not to defend or increase possessions they hold to the exclusion of others, but aim instead at shaping conditions beyond their national boundaries. […]
>
> Milieu goals often may turn out to be nothing but a means … toward some possession goal. A nation may hope to increase its prestige or its security by making sacrifices for the establishment and maintenance of international organizations. But this need not be its exclusive aim. Instead, the nation in question may be seriously concerned about the milieu within which it operates and may expect such organizations to improve the environment by making it more peaceful or more conducive to social or economic progress.[415]

In other words, possession goals increase our sense of security directly. Milieu goals increase our sense of security by making the environment less uncertain. The milieu goal can be altruistic, utopia seeking, but often seeking milieu goals is to seek selfish goals.

Wolfers, therefore, understands the balance of power, but he shows that states will often go beyond balancing, emphasizing that interaction within the social setting is a means by which

[415] Wolfers, 73-74.

states can alternatively increase their security needs by making the world more predictable on their own terms.

This study emphasizes that states seeking to maximize security can do so better through social interaction, increasing global transparency and other multilateral goals, by diverting our attention away from solely power as a means towards security. This is not to say that we will always supersede our primary possession goals.

Wolfers notes that if a state faces nuclear annihilation, it will cede to the state threatening it because keeping its citizens (and itself) alive is more important than any other goal (including other possession goals).[416] In Chapter 2 I make the case for this study's urgency. But it also notes that, if for no other reason outlined in the rest of this study, states will take disarmament very seriously in the event of even a small nuclear war. The demonstration of the existential threat nuclear weapons pose and the global aftermath of nuclear exchange will give states the options to possess nuclear weapons without the certainty of deterrence or world to eliminate them at the global level in a way that is—more or less—certain, depending on how much authority with which the states wish to empower the IAEA. That is, working to shape the milieu in this setting better serves the national interest than its possessions.

None of this means, however, that disarmament is inevitable given the development of an international reality where Colin Gray would say disarmament is possible only because it is possible for the time being. Nuclear weapons are firmly embedded in the international structure. Even if Mueller is correct that nuclear weapons have served their purpose and are obsolescent, it could be simply that shining a light on them during dismantlement makes them very relevant again. States will continue to endow their possession goals with more important when necessary.

---

[416] Wolfers, 79.

9.4 What about the Outlier States?

Outlier participation is key. Although the model does not maximize Outlier States,[417] and although it merely weakly increases their prestige (permanently), the model does not function without increasing our acceptance of the Outlier States. Various exploratory simulations during the early stages of the model revealed that there is unlikely a feasible way to satisfy Outlier States without directly engaging them. In this sense, it is not unreasonable that US President Trump parted ways with the longstanding tradition of not meeting with the Supreme Leader of North Korea in 2018. He instead chose to legitimize the Supreme Leader, something the DPRK has wanted for generations. This resulted in better relations between the US and the DPRK. Rather than isolation, states outlying the NPT are much more receptive when they are brought into the international fold.

This does not mean merely including them in negotiations, although that is obviously very important. Rather, it means reducing or eliminating economic sanctions, bringing them into the Nuclear Suppliers Group (with specific safeguards provisions for components and materials obtained), temporarily forgiving human rights violations until the treaty is ratified,[418] and recognizing them as nuclear powers. This last step might require invoking Article VIII, paragraph 1 of the NPT, which gives Parties to the Treaty the right to propose amendments to the NPT. Specifically, the proposed amendment would update the text of Article IX, paragraph 3, which defines legal nuclear weapons states as any state with nuclear weapons prior to January 1967. Updating this cutoff date to a future date would legitimize India's (first weapon, 1974), Pakistan's (1998), and North Korea's (2006) nuclear programs, as well as Israel's undeclared

[417] Maximizing the Outlier would be to focus solely on its needs.
[418] This might be particularly unpopular in democratic regimes, exacerbating the problem. It might be necessary, however, in order to remain nuclear focused and not become sidetracked by other humanitarian concerns.

weapons (likely 1979). This might be politically unpopular domestically, especially in states identified in my model as NPT States, which presents a new set of problems; however, it might be crucial to getting the Outlier States onboard with the NPT. Getting the DPRK, India, Israel, and Pakistan in good standing with the NPT also weds them to Article VI, which requires they make good faith efforts towards disarmament. Wedding the Outlier States to the NPT therefore has a legitimizing effect on Article VI. In order for the P5 states to call on the DPRK to disarm under Article VI, it requires that the P5 acknowledge that it also shares a duty to disarm.

Furthermore, bringing in the Outlier States to the international fold vis a vis the Nuclear Suppliers Group for India, Israel, and Pakistan, or in general for the DPRK also legitimizes and reinforces the norm of international cooperation. In the same way that West Germany and Japan were included in rebuilding the international system following World War II, including the Outlier States, particularly the DPRK, demonstrates that the international community is sensitive to all of their needs, not merely whether or not they possess nuclear weapons.

The adapted realism I use in this study, particularly in Chapter 2, suggests that the likely candidates for nuclear war are among the Outlier States. India and Pakistan have danced close to the brink a few times, and during summer 2017 the DPRK came too close for comfort to a nuclear attack by the US. Traditional realist logic tells us the DPRK would be foolish to give up its nuclear deterrent because it remembers General MacArthur almost overthrowing it in 1950, and it watched Iran, Iraq, and Libya all suffer recent punishments despite giving up their nuclear programs. On the other hand, this form of realism suggests the DPRK's survival might be better guaranteed without nuclear weapons. The worst-case scenario is: with nuclear weapons it risks being completely annihilated. Surviving nuclear war offers the DPRK a probability of zero. Without nuclear weapons, it risks only a bloody conventional war. The probability of surviving a

conventional war is a non-zero number. Therefore, getting the DPRK to the negotiating table is not as difficult as one might imagine (indeed, we've already seen it). And once the Outlier States are at the disarmament-negotiating table, the P5 states are more likely to take their own obligations under NPT Article VI seriously.

9.5 Can We Stay There?

It would be foolish to assume that once we've arrived at global zero we can stay there permanently. The knowledge of fission is a permanent fixture in the minds of scientists, barring a global cataclysm that knocks human beings back to the Stone Age (perhaps a nuclear war). Although, as already acknowledged, this does not mean nuclear weapons are permanent fixtures, but it is (hopefully) unlikely human beings will ever forget how to split the atom.

Because this knowledge has staying power, nations will have to live with a natural tendency towards nuclear bipolarity. Quester illustrates this using a mathematical notation with realist theory:[419]

$$'0' > 1 < 2 > 3 > 4 \ldots n$$

where three nuclear weapons states are preferable to four, and two are preferable to three, but one is not preferable to two because then a single state would have the capability to dominate international politics, forcing another state to balance. And zero may be preferable to one, but states' natural skepticism towards each other means that at some point, one state is going to preemptively balance against a perceived future proliferator, causing a balancing move by

[419] Quester, 205.

another state, self-fulfilling the prophesy towards two nuclear weapons states. Waltz argues this is the preferred state of international politics, writing the bipolar system compels bipolar focus, where the actions of one superpower dominate the attention of the other; the bipolar system makes small losses tolerable; and the bipolar system keeps pressure on both sides through continued crises, which causes both powers to exercise continued caution (with nuclear weapons).[420] Quester and Waltz, taken together, imply that in the disarmed world a small crisis (such as the one I hypothesize in Chapter 8, which began with Japanese fishermen getting stranded on a manmade Chinese island that served as a small naval base) might spiral out of control until two sides reconstitute at least a first strike capability. Once rearmament has been achieved, the system will cease its spiral and stabilize. The war will likely de-escalate once nuclear weapons are reintroduced.[421]

Traditional realist thought tells us that the disarmed world is only temporary and that there will be tremendous pressure to shift away from zero nuclear weapons states to at least two nuclear weapons states. O'Hanlon accepts this logic but adds that nuclear disarmament should be a goal, but not a permanent solution.[422] What realists, including O'Hanlon, do not show us is what happens once a disarmament treaty is signed. Does the signing of a treaty violate realist thinking? It depends on what matters.

Immediate cheating (i.e. hiding away a couple dozen or so weapons before opening your doors to IAEA inspectors[423]) notwithstanding, my model shows step-by-step effects on security. Most notable is the net gain in security without nuclear weapons, which defies realist thinking.

---

[420] Waltz (1964), 882-884.
[421] Waltz (1981), 5.
[422] O'Hanlon, Kindle location 937.
[423] Hopefully, the IAEA inspectors and treaty negotiators take this possibility very seriously and work out a solution before the treaty is sent for ratification.

Realists, however, might simply point to my "security period of vulnerability" as the point where the disarmament treaty falls apart. On the other hand, it is possible that realist thinking here is incorrect (or at least needs to be slightly altered) for two related reasons. First, as I write in Chapter 2, nuclear war is unlikely, but unlikely things happen all the time. Because the probability of a nuclear war between two nations is not zero, nuclear war between two nations *will occur* on a long enough timeline. It might be possible for states to look ahead far enough into the future and see that their survival is more guaranteed without nuclear weapons than with, as the model suggests at its end state. Second, if realists assume states are always calculating cost and benefit, and that they will act to maximize their security, then they will be better off under disarmament. If zero represents the status quo, and if the end state gives us a maximum increase in security, then realist thinking about nuclear weapons should be updated to reflect that a disarmed world is more secure than an armed world.

Additionally, mechanisms to prevent war are inherently a part of my model vis-à-vis the re-proliferation capabilities. Schell, Schelling,[424] O'Hanlon, Acton, and Perkovich each understand the need for short order rearmament capabilities in order to stabilize developing international crises. O'Hanlon, Acton, and Perkovich do not appear concerned with small crises. They might not notice my anecdote of the Japanese fishermen, China's response, and the former nuclear powers' overreaction to China's response. They might only notice once leaders begin to rethink their nuclear options and support that move in order to re-stabilize the system. Schell is a little more concerned with the small crises. He believes that the small crises are unlikely to spiral because former nuclear weapons states, enjoying a short-order re-proliferation capability, carry

[424] Schelling (2009), 126.

with them "weaponless deterrence."[425] Schell argues that in a world with short-order rearmament capabilities, the state of nature is proliferation deterrence, which guides states' responses. In this case, Schell might notice when the former nuclear powers reacted, but it is likely it would have stopped there. Realist thinking implies the Japanese fishermen will likely meet an untimely execution by Chinese officials simply because it is not in Japan's national interest to start a skirmish that leads to a nuclear China. Accordingly, even if Japan called on the superpowers for help, they, not wanting a nuclear China, would likely merely attempt to exhaust their diplomatic capabilities. If they could not get the Japanese prisoners freed using diplomacy, it would stop there. Wheeler and Booth support Schell's assessment (with a subsequent short critique), calling it "an intellectual *tour de force*."[426]

My argument in Chapter 8, using the extensive form game, is that this is structural. States are cost-benefit calculators, and they know that every move they make either leads them towards security through MAD, which is a costly path to follow, or security through threat avoidance. China might have called on Japan's ambassador to explain the situation, rather than escalating the situation. Because in my model the re-proliferation capabilities are automatic,[427] there is little room for mistake in international affairs.

The implication of this automatic re-proliferation capability is that it might compel peaceful relations, giving states usually hostile towards each other the ability to find alternative ways of living with one another. The Koreas might engage in trade simply because trade is a better alternative than war, leading to more trust. Trust begets trust. And on a long enough timeline, the realist edicts telling states to calculate cost and benefit might not even need to

---

[425] Schell, 158.
[426] Wheeler and Booth, 36.
[427] If policy-makers are paying attention.

assume the costs include war. Can there be perpetual peace through "weaponless deterrence"? It is unlikely, but it is also not beyond possibility.

In other words, it is possible to stay at disarmament, but staying there requires automatic re-proliferation capabilities that discourage testing the re-proliferation rule.

9.6 Disarmament, Complexity, and the Hurdles

This study began by analyzing two complex problems and then moved on to analyze known interactions between the problems. Movement in the mess takes us from less order to more order. Kurtz and Snowden phrase this movement as "shifting a system from complexity to order and maintaining it there in such a way that it becomes predictable."[428] This study illuminates that unknown-knowns existed within the mess. The knowledge was there, but we did not yet understand it. The interactions between problems and nodes within the problems and "mess" refine our understanding so that we are left with known-unknowns. In other words, the security dilemma during the "security period of vulnerability" is still a problem, but we can act towards disarmament in a way that is predictable and beneficial.

As stated before, this study reveals the enormity of the "mess" complexity. It is far more complex than realist power calculations suggest. The realist, while focused on power capability, misses the net security increase offered by multilateral disarmament that erases nuclear weapons' existential threat to the human species. It also misses the net security increases caused by increased cooperation and transparency (negotiated in the disarmament treaty). The realist might argue this is temporary, but that would require the realist to assume states are not security maximizers on a long enough timeline. It also illuminates that the "mess" is even more complex

[428] Cynthia Kurtz, and David Snowden, "The New Dynamics of Strategy: Sense-making in a Complex and Complicated World," *IBM Systems Journal* 42, no. 3 (2003): 465.

than the Sagans and Booths of realism. Yes, the international system can work towards disarmament, but it requires acknowledging several competing moving parts in a system. When problems get more complex than the realist assumes they can get, then the realist needs to expand his or her tool set. It finally illuminates that the issue's complexity means that abolitionists need a better understanding of cause and effect. The "security period of vulnerability" is a very serious issue that could undermine the entire disarmament process, lead to conventional war, and maybe to a nuclear exchange, fulfilling the abolitionists' nuclear holocaust hypothesis. The abolitionist needs to accept that periodic nuclear reconstitution is a good thing.

The hurdles that are holding states to their nuclear weapons are not necessarily structural. If they are structural, then there is a competing structure working against them—human empathy for others. And if the hurdles are not structural, then realists need to admit that humans, and therefore states, have agency to choose to balance or to do something else. The disputes in Eastern Europe, the South China Sea, Kashmir, the Middle East, Taiwan, and Korea are manageable (perhaps using fuzzy cognitive mapping to maximize states' security needs). The remaining known-unknowns are also manageable. Sovereignty and its resultant anarchy, security dilemmas, uncertainty, among others can all be mitigated through understanding the complex relationships between problem components and between problems.

Once these known-unknowns are managed and a successful disarmament treaty is signed, two competing scenarios are possible (illustrated in Scenarios 7 and 8, respectively). First, long-term disarmament under the threat of re-proliferation is viable as long as *states* take their international commitments seriously. If total nuclear security is a milieu goal, then these commitments enact some level of benefit. Second, a similar long-term disarmament is also viable

as long as the *IAEA* takes its responsibilities seriously at the expense of the former nuclear powers. In other words, either the states empower the IAEA to a degree commensurate to milieu goals or, if disarmament is still preferable without much state participation, the IAEA will decide states' possession goals despite the states' wishes. It is far more likely that a viable path forward requires that states shift their understanding of security beyond mere focus on the possession of power and towards creating a milieu where no one wants to possess nuclear weapons. IAEA empowerment should be limited by the scope of the milieu; otherwise, a disarmed world looks unrecognizable.

To summarize this my findings, I propose that global nuclear disarmament is not unthinkable, but temporary disarmament is more viable than a permanent solution. This acknowledges that in addition to the milieu goals states possess, which compel them to work toward a world without the threat of nuclear war, states' possession goals make permanent disarmament unlikely, unless, of course, the milieu changes significantly in the future. Therefore, I am skeptically optimistic. The path forward requires us to think less about our internal national security, and more towards how our national security can be gained through social interactions. But we must not forget that ultimately the balance of power and the threat of death are compelling and unalterable reasons it is a good thing we are stuck with nuclear knowledge.

A final note that the realist either does not see or does not think is important: For the bulk of this study, I have viewed the nuclear problem as significant because the probability of nuclear war is not zero and the costs of nuclear war reach infinity (human extinction). But the problem is actually defined by a point made in Chapter 5 (Problem 1). That is, all stakeholders, including nuclear weapons states and Outlier States, agree that nuclear weapons are a problem and that abolishing them is a (milieu) goal. If nuclear weapons states and Outlier States did not view them

as a problem, they would simply ignore the problem. The fact that they have chosen to participate in this debate highlights that power is not the only concern states have. Security through MAD is not as reassuring as realists might believe. This study illuminates the complexities that make this a reality. This study shines a light on the way states shape the milieu and are compelled to act according to these external circumstances.

BIBLIOGRAPHY

"Could Food Shortages Bring Down Civilization?" *UPI Space Daily*. October 08, 2009.

“Drawing safeguards conclusions.” International Atomic Energy Agency. Last modified 2017, https://www.iaea.org/topics/drawing-safeguards-conclusions.

“International Court of Justice: Advisory Opinion on the Legality of the Threat or Use of Nuclear Weapons.” *International Legal Materials* 35, no. 4 (1996): 809-938.

“Nonproliferation Policy and Implementation Group.” Brookhaven National Laboratory, https://www.bnl.gov/NNS/policy.php.

“North Korea Facilities: Missile Map.” *Nuclear Threat Initiative*. http://www.nti.org/gmap/missile_north_korea.html.

“Nuclear Energy Prospects in New Zealand.” *World Nuclear Association*. April 2017. http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/new-zealand.aspx.

“Nuclear power is part of the problem.” Greenpeace, last modified July 1, 2016. https://www.greenpeace.org/archive-international/en/campaigns/climate-change/Solutions/Reject-false-solutions/No-to-nuclear/.

“Resolution On Multilateral Arms Control.” *Southern Baptist Convention,* 1978.

“Safeguards and verification.” International Atomic Energy Agency. Last modified February 2018, https://www.iaea.org/topics/safeguards-and-verification.

“Statute.” Article II. *International Atomic Energy Agency*. Vienna, Austria, December 1989.

“The nuclear explosion in North Korea on 3 September 2017: A revised magnitude assessment.” *NORSTAR*. September 12, 2017. https://www.norsar.no/press/latest-press-release/archive/the-nuclear-explosion-in-north-korea-on-3-september-2017-a-revised-magnitude-assessment-article1548-984.html.

“Treaties under IAEA Auspices.” International Atomic Energy Agency, https://www.iaea.org/resources/treaties/treaties-under-IAEA-auspices.

Acheson, Ray. “Foregrounding Justice in Nuclear Disarmament: A Practitioner Commentary,” *Global Policy* 7, no. 3 (2016): 405-407.

Ackoff, Russell L. “Optimization + Objectivity = Opt Out.” *European Journal of Operational Research* 1, no. 1 (1977): 1-7.

Ackoff, Russell L. “The Future of Operational Research Is Past.” *The Journal of the Operational Research Society* 30, no. 2 (1979): 93-104.

Ackoff, Russell L. “The Systems Revolution.” *Long Range Planning* 7, no. 6 (1974): 2-20.

Adams, Kevin MacG. and Patrick T. Hester. “Accounting for errors when using systems approaches,” *Procedia Computer Science* 20 (2013): 318-324.

Allison, Graham T. *Destined for War: Can America and China Escape Thucydides’s Trap?* New York: Houghton Mifflin Harcourt, 2017. Kindle edition.

Allison, Graham T. “The Thucydides Trap.” *Foreign Policy*, June 9, 2017. https://foreignpolicy.com/2017/06/09/the-thucydides-trap/.

Amano, Yukiya. *Technical Cooperation: Report for 2014*. Vienna: International Atomic Energy Agency, 2015, https://www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-3_en.pdf.

Anderson, Ewan W, Liam D. Anderson, and Ian Cool. *An Atlas of Middle Eastern Affairs*. E-book. Second edition. London: Taylor & Francis Group, 2014.

Aramel, Saul. “On the mechanization of creative processes.” *IEEE Spectrum* 3, no. 4 (1966): 112-114.

Axelrod, Robert. *The Evolution of Cooperation: Revised Edition*. New York, New York: Basic Books, 2006. Kindle edition

Axelrod, Robert M. *Structure of Decision: The Cognitive Maps of Political Elites*. Princeton, N.J.: Princeton University Press, 1976.

Bailey, Sarah Pulliam. “‘God has given Trump authority to take out Kim Jong Un,’ evangelical adviser says.” *The Washington Post*, August 9, 2017, https://www.washingtonpost.com/news/acts-of-faith/wp/2017/08/08/god-has-given-trump-authority-to-take-out-kim-jong-un-evangelical-adviser-says/.

Baudrillard, Jean. *The Gulf War did not take place*. Sydney: Power Publications, 2018.

Baum, Seth D. "Confronting the Threat of Nuclear Winter." *Futures* 72 (2015): 69-79.

Blackwill, Robert D. and Jennifer M. Harrison. *War by Other Means: Geoeconomics and Statecraft*. Cambridge: Harvard University Press, 2016.

Blanchard, Benjamin S. *System Engineering Management*. 3rd edition. Hoboken, NJ: John Wiley, 2004.

Boal, Kim and Mark Meckler. “Decision Errors of the 4th, 5th, and 6th Kind.” In *Handbook of Decision Making: Blackwell Encylopaedia of Management*. E-book, edited by Paul C. Nutt and David C. Wilson. West Sussex: Wiley, 2010.

Bohr, N. “The Quantum Postulate and the Recent Development of Atomic Theory.” *Nature* 121, no. 3050 (1928): 580-590.

Booth, Ken. “Security in Anarchy: Utopian Realism in Theory and Practice.” *International Affairs* 67, no. 3 (1991): 527-545.

Booth, Ken and Nicholas J. Wheeler. “Beyond nuclearism.” In *Security Without Nuclear Weapons: Different Perspectives on Non-Nuclear Security*, edited by Regina Cowen Karp. New York: Oxford University Press, 1992.

Boureston, Jack, and Charles D. Ferguson. "Strengthening Nuclear Safeguards: Special Committee To the Rescue?" *Arms Control Today* 35, no. 10 (2005): 17-22.

Bradley, Omar. “Military Situation in the Far East.” Hearings, 82d Congress, 1st session, part 2, p. 732. May 15, 1951.

Brams, Steven J. *Superpower Games: Applying Game Theory to Superpower Conflict*. New Haven: Yale University Press, 1985.

Bressan, David. “Even A Small Nuclear War Would Still Have Effects On Global Scale.” *Forbes*. August 12, 2017. https://www.forbes.com/sites/davidbressan/2017/08/12/even-a-small-nuclear-war-would-still-have-effects-on-global-scale/#62f8de84507d.

Briffa, K., P. Jones, F. Schweingruber, and T. Osborn. "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperature over the past 600 Years." *Nature* 393, no. 6684 (1998): 450-455.

Brodie, Bernard. *Strategy in the Missile Age*. Princeton, N.J.: Princeton University Press, 1959.

Bueno de Mesquita, Bruce and William H. Riker. “An Assessment of the Merits of Selective Nuclear Proliferation,” *Journal of Conflict Resolution* 26, no. 2 (1982): 283-306.

Bueno, Salvador and Jose L. Salmeron. “Benchmarking Main Activation Functions in Fuzzy Cognitive Maps.” *Expert Systems with Applications* 36, no. 3 (2009): 5221-5229.

Bull, Headley, “Rethinking Non-Proliferation” *International Affairs* 51, no. 2 (1975): 195-189.

Bunn, Matthew. "A Mathematical Model of the Risk of Nuclear Terrorism." *The Annals of the American Academy of Political and Social Science* 607, no. 1 (2006): 103-20.

Carr, E.H. *The Twenty Years’ Crisis, 1919-1939*. New York: HarperCollins, 1946.

Cénat, Jude Mary and Daniel Derivois. "Assessment of Prevalence and Determinants of Posttraumatic Stress Disorder and Depression Symptoms in Adults Survivors of Earthquake in Haiti after 30 Months." *Journal of Affective Disorders* 159 (2014): 111-117.

Cerny, Phillip G. *Rethinking World Politics: A Theory of Transnational Neopluralism*. New York: Oxford University Press, 2010. Kindle edition.

Churchman, Charles West. "Wicked Problems." *Management Science* 14, no. 4 (1967): B141-B142.

Clemen, Robert T. and Terence Reilly. *Making Hard Decisions with Decision Tools*. 3rd Edition. Boston: Cengage Learning, 2013.

Cooley, Jill N. "State-Level Concept Information." Lecture presented at the Nuclear Nonproliferation, Safeguards, and Security in the 21st Century course. Brookhaven National Laboratory, Upton, NY, June 2018.

Costa, Eugenio Pacelli Lazzarotti Diniz. "Brazil's Nuclear Submarine: A Broader Approach to Safeguards Issues." *Revista Brasileira De Política Internacional* 60, no. 2 (2017): 1-20.

Covey, Curt. "Climatic Effects of Nuclear War." *BioScience* 35, no. 9 (1985): 563-69.

Curtis, N. J., P. J. Dortmans, and J. Ciuk. "'Doing the Right Problem' versus 'doing the problem right': problem structuring within a Land Force Environment." *Journal of the Operational Research Society* 57, no. 11 (2006): 1300-312.

Dass-Brailsford, Priscilla, Rebecca S. Hage Thomley, Nicholas W. Talisman, Katherine Unverferth, and Bride, Brian E. "Psychological Effects of the 2010 Haitian Earthquake on Children: An Exploratory Study." *Traumatology* 21, no. 1 (2015): 14-21.

Dawkins, Richard. *The Selfish Gene: 40th Anniversary Edition*. Oxford: Oxford University Press, 2016. Kindle Edition

Deschamps, Etienne. "The Political Consequences." *CVCE*. July 8, 2016. https://www.cvce.eu/obj/the_political_consequences-en-bafcfa2d-7738-48f6-9b41-3201090b67bb.html.

Durkheim, Émile. *Suicide: A Study in Sociology*. Glencoe, IL: The Free Press, 1951.

Emanuel, K. A. "Nuclear Winter: Towards a Scientific Exercise." *Nature* 319, no. 6051 (1986): 259.

Erickson, Stanley A. "Economic and technological trends affecting nuclear nonproliferation." *The Nonproliferation Review* 8, no. 2 (2001): 40-54.

Fischer, Georges. *The Non-proliferation of Nuclear Weapons*. London: Europa, 1971.

Fukuyama, Francis. "The End of History?" *The National Interest*, no. 16 (1989), 3-18.

Ghosh, Amitav. *Countdown*. New Delhi: Pengui Books India, 2008.

Gibbard, Allan. Allan Gibbard, "Manipulation of voting schemes: A general result." *Econometrica* 41, no. 4 (1973): 587-601.

Garwin, Richard L. "Technologies and procedures for verifying warhead status and disarmament." In *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions*, edited by Nicholas Zarimpas. Solna, Sweden: Oxford University Press, 2003.

Gass, Saul I. "Model World: On the Evolution of Operations Research." *Interfaces* 41, no. 4 (2011): 389-393.

Gray, Colin S. *House of Cards Why Arms Control Must Fail*. Ithaca: Cornell University Press, 1992.

Gray, Steven. "Mental Modeler." http://www.mentalmodeler.org/.

Greeno, James G. and George Mandler. "Indefinite Goals in Well-structured Problems." *Psychological Review* 83, no. 6 (1976): 479-491.

Guerra, Hector. "Ban the Bomb? A Mexican Response." *Bulletin Of The Atomic Scientists* 70, no. 6 (2014): 18-21.

Harrington, Anne I., Eliza Gheorghe, and Anya Loukianova Fink. "What Arguments Motivate Citizens to Demand Nuclear Disarmament?" *Bulletin Of The Atomic Scientists* 73, no. 4 (2017): 255-263.

Häckel, Erwin. "Towards non-nuclear security: costs, benefits, requisites." In *Security Without Nuclear Weapons: Different Perspectives on Non-Nuclear Security*, edited by Regina Cowen Karp. New York: Oxford University Press, 1992.

Harrington De Santana, Anne. *Nuclear Weapons as a Currency of Power: Deconstructing the Fetishism of Force*, 2010, ProQuest Dissertations and Theses.

Haselton, Martie G. "Error Management Theory." In *Encyclopedia of Social Psychology*, edited by Roy F. Baumeister and Kathleen D. Vohs. Thousand Oaks, CA: SAGE Publications, Inc., 2007.

Haselton, Martie G. and David M. Buss. "Biases in Social Judgment: Design Flaws or Design Features?" In *Social Judgments: Implicit and Explicit Processes*, edited by Joseph P.

Forgas, Kipling D. Williams, and William Von Hippel, 23-43. New York: Cambridge University Press, 2003.

Haskel, Barbara G. "Access to Society: A Neglected Dimension of Power," *International Organization* 34, no. 1 (1980), 89-120.

Hersh, Seymour M. *The Samson Option: Israel's Nuclear Arsenal and American Foreign Policy*, 1st edition. New York: Random House, 1991.

Herz, John H. "Idealist Internationalism and the Security Dilemma." *World Politics* 2, no. 2 (1950): 157-180.

Hester, Patrick T. "Analyzing Stakeholders Using Fuzzy Cognitive Mapping." *Procedia Computer Science* 61 (2015): 92-97.

Hester, Patrick T. and Kevin MacG. Adams. *Systemic Decision Making: Fundamentals for Addressing Problems and Messes*. 2nd edition. Springer International, 2017.

Hobbes, Thomas. *Leviathan, Or, The Matter, Forme and Power of a Common Wealth, Ecclesiasticall and Civil*. E-book. London: Early English Books Online, 1651.

Holland, Paul W. "Statistics and Causal Inference." *Journal of the American Statistical Association* 81, no. 396 (1986): 946-960.

Hoye, Daniel F. "The Challenge of Peace: God's Promise and Our Response." *National Conference of Catholic Bishops*. May 3, 1983.

Huntington, Samuel P. *The Clash of Civilizations and the Remaking of World Order*. New York: Simon & Schuster, 1996.

Hymans, Jacques E. C. "THEORIES OF NUCLEAR PROLIFERATION: The State of the Field." *The Nonproliferation Review* 13, no. 3 (2006): 455-465.

Jetter, Antoine and Kasper Kok. "Fuzzy Cognitive Maps for Futures Studies—A Methodological Assessment of Concepts and Methods." *Futures* 61 (2014): 45-57.

Jetter, Antoine and Willi Schweinfort. "Building Scenarios with Fuzzy Cognitive Maps: An Exploratory Study of Solar Energy." *Futures* 43, no. 1 (2011): 51-66.

Karp, Regina. "Nuclear Disarmament: Should America Lead?" *Political Science Quarterly* 127, no. 1 (2012): 47-71.

Karp, Regina Cowen. "Introduction." In *Security with Nuclear Weapons? Different Perspectives on National Security*, edited by Regina Cowen Karp. Oxford; New York: Oxford University Press, 1991.

Katz, Arthur and Sima R. Osdoby. “Cato Institute Policy Analysis No. 9: The Social and Economic Effects Of Nuclear War.” *CATO Institute*. April 21, 1982. https://object.cato.org/sites/cato.org/files/pubs/pdf/pa009.pdf.

Keohane, Robert O. “Theory of World Politics: Structural Realism and Beyond.” In *Neorealism and Its Critics*, edited by Robert O. Keohane. New York: Columbia University Press, 1986.

Kittel, Charles. “The Nature and Development of Operations Research.” *Science* 105, no. 2719 (1947): 150-153.

Kosko, Bart. “Fuzzy Cognitive Maps.” *International Journal of Man-Machine Studies* 24 (1986): 65-75.

Kristensen, Hans M., and Robert S. Norris. “Status of World Nuclear Forces.” *Federation of American Scientists*. July 8, 2007. https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.

Kristensen, Hans M., and Robert S. Norris. "US Nuclear Forces, 2014." *Bulletin of the Atomic Scientists* 70, no. 1 (2014), 86

Kuhn, Thomas and Harold A. Linstone. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press, 1962.

Kurtz, Cynthia, and David Snowden. "The New Dynamics of Strategy: Sense-making in a Complex and Complicated World." *IBM Systems Journal* 42, no. 3 (2003): 462-483.

Larsen, Jeff A. and James M. Smith. *Historical Dictionary of Arms Control and Disarmament*. Maryland: Scarecrow Press, Inc. 2005.

Likert, Rensis. “A Technique for the Measurement of Attitudes.” *Archives of Psychology* 22, no. 140 (1932): 55.

Liska, Adam, Tyler White, Eric Holley, and Robert Oglesby. "Nuclear Weapons in a Changing Climate: Probability, Increasing Risks, and Perception." *Environment* 59, no. 4 (2017): 22-33.

Lüthi, Lorenz. “The Non-Aligned Movement and the Cold War, 1961-1973.” *Journal of Cold War Studies* 18, no. 4 (2016): 98-147.

Maclin, Beth. “A nuclear weapon-free world is possible, Nunn says.” *Belfer Center for Science and International Affairs*. October 20, 2008. https://www.belfercenter.org/publication/nuclear-weapon-free-world-possible-nunn-says.

Marascuilo, Leonard A. and Joel R. Levin. “Appropriate Post Hoc Comparisons for Interaction and Nested Hypotheses in Analysis of Variance Designs: The Elimination of Type IV Errors.” *American Educational Research Journal* 7, no. 3 (1970): 397-421.

Maslow, A. H. and Herbert S. Langfeld. “A Theory of Human Motivation.” *Psychological Review* 50, no. 4 (1943): 370-396.

McGinnis, Michael D. "Issue Linkage and the Evolution of International Cooperation." *Journal of Conflict Resolution* 30, no. 1 (1986): 141-70.

Mearsheimer, John J. “Back to the Future: Instability in Europe after the Cold War.” *International Security* 15, no. 1 (1990): 5-56.

Mearsheimer, John J. Radio interview, “Morning Edition,” *National Public Radio*, June 21, 1993

Mearsheimer, John J. “The Case for a Ukrainian Nuclear Deterrent,” *Foreign Affairs* 72, no. 3 (Summer 1993): 50-66.

Miles, Tom. “U.N. chief calls for new push to rid the world of nuclear weapons.” *Reuters*. February 26, 2018, https://www.reuters.com/article/us-un-arms/u-n-chief-calls-for-new-push-to-rid-the-world-of-nuclear-weapons-idUSKCN1GA1TK.

Millet, I. and J. L. Gogan. “A Dialectical Framework for Problem Structuring and Information Technology.” *The Journal of the Operational Research Society* 57, no. 4 (2006): 434-442.

Mitchell, Ronald K., Bradley R. Agle, and Donna J. Wood. “Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts.” *The Academy of Management Review* 22, no. 4 (1997): 853-886.

Mitchem, Jamie D. "Survivor Guilt." In *Encyclopedia of Disaster Relief*, edited by K. B. Penuel and Matt Statler, 662-664. Thousand Oaks, CA: SAGE Publications, Inc., 2011.

Mitroff, Ian I. *Smart Thinking for Crazy Times: The Art of Solving the Right Problems*. San Francisco: Berrett-Koehler Publishers, 1998.

Mitroff, Ian I. and Harold A. Linstone. *The Unbounded Mind: Breaking the Chains of Traditional Business Thinking*. New York: Oxford University Press, 1995.

Mosteller, Frederick. “A k-Sample Slippage Test for an Extreme Population.” *The Annals of Mathematical Statistics* 19, no. 1 (1948): 58-65

Morgenthau, Hans J. *Politics among Nations: The Struggle for Power and Peace*. 4th edition. New York: Knopf, 1967.

Morrow, James D. *Game Theory for Political Scientists*. Princeton, N.J.: Princeton University Press, 1994.

Mueller, John E. "The Essential Irrelevance of Nuclear Weapons: Stability in the Postwar World." *International Security* 13, no. 2 (1988): 55-79.

Müller, Harald. "Out of the box: Nuclear disarmament and cultural change." In *Stable Nuclear Zero: The vision and its implications for disarmament policy*, edited by Sverre Lodgaard, 69-70. New Hampshire: Heinemann, 2017.

Newell, A, J.C. Shaw, and H.A. Simon. *Report on a General Problem Solving Program*. Technical Report No. P-1584. Santa Monica, CA: RAND Corporation, 1959.

Newman, Benjamin J. J. and Todd K. K. Hartman. "Mass Shootings and Public Support for Gun Control." *British Journal of Political Science*, 2017, 1-27.

Neyman, Jerzy and Egon Pearson. "On the Use and Interpretation of Certain Test Criteria for Purposes of Statistical Inference: Part I." *Biometrika* 20A, no. 1/2 (1928): 175-240.

Nye, Joseph S. "Soft power," *Foreign Policy* no. 80 (1990): 153-171.

O'Hanlon, Michael E. *A Skeptic's Case for Nuclear Disarmament*. Washington, D.C.: Brookings Institution Press, 2010. Kindle edition.

Oppenheimer, Clive. "Climatic, Environmental and Human Consequences of the Largest Known Historic Eruption: Tambora Volcano (Indonesia) 1815." *Progress in Physical Geography* 27, no. 2 (2003): 230-259.

Özesmi, Uygar, and Özesmi, Stacy L. "Ecological Models Based on People's Knowledge: A Multi-step Fuzzy Cognitive Mapping Approach." *Ecological Modelling* 176, no. 1 (2004): 43-64.

Papageorgiou, Elpiniki I. *Fuzzy Cognitive Maps for Applied Sciences and Engineering: From Fundamentals to Extensions and Learning Algorithms*. Dordrecht: Springer, 2013.

Pape, Robert Anthony. *Dying to Win: The Strategic Logic of Suicide Terrorism*. New York: Random House, 2005.

Pelzer, Norbert. "Safer Nuclear Energy through a Higher Degree of Internationalisation?: International Involvement versus National Sovereignty," *Nuclear Law Bulletin*, no. 1 (2013): 43-88.

Perkovich, George and James Acton. *Abolishing Nuclear Weapons*, Adelphi Papers 396. London: Routledge for The International Institute for Strategic Studies, 2008.

Pidd, Michael. “Complementarity in Systems Modeling.” In *Systems Modeling: Theory and Practice*, edited by Michael Pidd. Wiley, 2004.

Pidd, Michael. “From Problem-Structuring to Implementation.” *The Journal of the Operational Research Society* 39, no. 2 (1988): 115-121.

Pidd, Michael. *Tools for Thinking Modelling in Management Scienc.* 3rd edition. Chichester, U.K.: Wiley, 2009.

Pinker, Steven. *The Better Angels of Our Nature: Why Violence Has Declined*. New York: Penguin Publishing Group. Kindle Edition.

Pokras, Sandy. *Team Problem Solving: Reaching Decisions Systematically*. Revised edition. Fifty-Minute Series. Menlo Park, CA: Crisp Publications, 1994.

Postelnicescu, Claudia. "Europe’s New Identity: The Refugee Crisis and the Rise of Nationalism." *Europe's Journal of Psychology* 12, no. 2 (2016): 203-209.

Powell, Robert. “Absolute and Relative Gains in International Relations Theory.” *The American Political Science Review* 85, no. 4 (1991): 1303-1320.

Powell, Robert. *In the Shadow of Power: States and Strategies in International Politics*. Princeton: Princeton University Press, 1999.

Press, Daryl G., Scott D. Sagan, and Benjamin A. Valentino. "Atomic Aversion: Experimental Evidence on Taboos, Traditions, and the Non-Use of Nuclear Weapons." *The American Political Science Review* 107, no. 1 (2013): 188-206.

Quester, George H. “Nuclear proliferation and the elimination of nuclear weapons.” In *Security without Nuclear Weapons? Different Perspectives on Non-nuclear Security*, edited by Regina Cowen Karp, 210. Oxford; New York: Oxford University Press, 1992.

Rawls, John. *A Theory of Justice*. Cambridge, Mass.: Belknap Press of Harvard University Press, 1971.

Reiss, Mitchell B. “The Nuclear Tipping Point: Prospects for a World of Many Nuclear Weapons States.” In *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, edited by Kurt M. Campbell, Robert J. Einhorn, and Reiss B. Mitchell. Washington, DC: The Brookings Institution, 2004.

Richardson, Lewis F. *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War*, edited by Nicolas Rashevsky and Ernesto Trucco. Literary Licensing, LLC, 2012.

Richardson, Lewis F. “Linear Theory of Two Nations.” In *Collected Papers of Lewis Fry Richardson*, edited by Oliver M. Ashford, H. Charnock, P. G. Drazin, J. C. R. Hunt, P. Smoker, and Ian Sutherland. New York: Cambridge University Press, 1993.

Risler, Ed, Sara Kintzle, and Larry Nackerud. "Haiti and the Earthquake: Examining the Experience of Psychological Stress and Trauma." *Research on Social Work Practice* 25, no. 2 (2015): 251-256.

Rittel, Horst W. J. and Melvin M. Webber. “Dilemmas in a General Theory of Planning.” *Policy Sciences* 4, no. 2 (1973): 155-169.

Robock, A., L. Oman, G. L., Stenchikov, O. B. Toon, C. Bardeen, and R. P. Turco. "Climatic Consequences of Regional Nuclear Conflicts." *Atmospheric Chemistry and Physics* 7, no. 8 (2007): 2003-2012.

Robock, Alan. "Nuclear Winter Is a Real and Present Danger." *Nature* 473, no. 7347 (2011): 275-276.

Robock, Alan, and Owen Brian Toon. "Local Nuclear War, Global Suffering." *Scientific American* 302, no. 1 (2010): 74-81.

Rosenhead, J. “Past, Present and Future of Problem Structuring Methods.” *The Journal of the Operational Research Society* 57, no. 7 (2006): 759-765.

Russett, Bruce M. *The Prisoners of Insecurity: Nuclear Deterrence, the Arms Race, and Arms Control*. San Francisco: W.H. Freeman, 1983.

Sagan, Scott D. "Shared Responsibilities for Nuclear Disarmament.” *Daedalus 138*, no. 4 (2009): 157-168.

Sagan, Scott D. *The Limits of Safety Organizations, Accidents, and Nuclear Weapons*. Princeton, NJ: Princeton University Press, 1993.

Sagan, Scott D. and Kenneth N. Waltz. *The Spread of Nuclear Weapons: A Debate*. New York: W. W. Norton & Company, 1995.

Sage, Andrew. *Systems Engineering*. New York: Wiley-Interscience, 1992.

Sang-Hun, Choe and Mark Landler. “North Korea Signals Willingness to ‘Denuclearize,’ South Says,” *The Washington Post*, March 6, 2018, https://www.nytimes.com/2018/03/06/world/asia/north-korea-south-nuclear-weapons.html.

Satterthwaite, Mark Allen. “Strategy-proofness and Arrow’s conditions: Existence and correspondence theorems for voting procedures and social welfare functions.” *Journal of Economic Theory* 10, no. 2 (1975): 187-217.

Savage, Grant T., Timothy W. Nix, Carlton J. Whitehead. “Strategies for Assessing and Managing Organizational Stakeholders.” *The Executive* 5, no. 2 (1991): 61-75.

Savelsberg, Ralph and James Kiessling. “Was North Korea’s July 4th Surprise A Mobile Launched ICBM?” *Breaking Defense*. July 21, 2017. https://breakingdefense.com/2017/07/was-north-koreas-july-4th-surprise-a-mobile-launched-icbm/.

Schell, Jonathan. “The Abolition.” Reprinted in *The Fate of the Earth, and The Abolition*. Stanford, CA: Stanford University Press, 2000.

Schelling, Thomas. "A World without Nuclear Weapons?" *Daedalus* 138, no. 4 (2009): 124-129, 171.

Schelling, Thomas C. *Arms and Influence*. New Haven: Yale University Press, 1966.

Schelling, Thomas. *The Strategy of Conflict*. Cambridge, Massachusetts: Harvard University Press, 1980.

Schelling, Thomas C. “Surprise Attack and Disarmament.” *Bulletin of the Atomic Scientists* 15, no. 10 (December 1959): 413-418.

Schiff, Benjamin. *Dual Mandate: Safeguards and Technology Transfer in the International Atomic Energy Agency*, Ph.D. dissertation. University of California, Berkeley, 1982.

Schubert, Klaus. “France.” In *Security with Nuclear Weapons?: Different Perspectives on National Security*, edited by Regina Cowen Karp. New York: Oxford University Press, 1991.

Serfaty, Simon. “Moving into a Post-Western World.” *Washington Quarterly* 34, no. 2 (2011): 7-23.

Shultz, George P., William J. Perry, Henry A. Kissinger Sam Nunn. "A World Free of Nuclear Weapons." *Wall Street Journal* (New York, N.Y.), 2007.

Sidhu, Waheguru Pal Singh. “Nuclear Proliferation.” In *Security Studies: An Introduction*, edited by Paul D. Williams. New York, NY: Routledge, 2008.

Smith, Gerald F. “Towards a Heuristic Theory of Problem Structuring.” *Management Science* 34, no. 12 (1988): 1489-1506.

Smith, J, and T. Smith. "Attitudes towards Civil Defence and the Psychological Effects of Nuclear War." *British Medical Journal (Clinical Research Ed.)* 283, no. 6297 (1981): 963-965.

Sterman, John. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston: McGraw-Hill Higher Education, 2000.

Sterman, John D. “A Skeptic's Guide to Computer Models.” In *Managing a Nation: The Microcomputer Software Catalog*, Gerald O. Barney, W. Brian Kreutzer, Martha J. Garrett, W. Brian Kreutzer, 209-229. Boulder, CO: Westview Press 1993.

Sterman, John D. "All Models Are Wrong: Reflections on Becoming a Systems Scientist." *System Dynamics Review* 18, no. 4 (2002): 501-31.

Tannenwald, Nina. “The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use.” *International Organization* 53, no. 3 (1999): 433-468.

Thucydides. *The History of the Peloponnesian War*. Translated by Richard Crawley. 431 BCE. Kindle Edition.

Thurlow, Setsuko. "NUCLEAR WAR IN HUMAN PERSPECTIVE: A Survivor's Report." *American Journal of Orthopsychiatry* 52, no. 4 (1982): 638-645.

Toon, Owen, Alan Robock, Richard Turco, and Charles Bardeen. "Consequences of Regional-Scale Nuclear Conflicts." *Science* 315, no. 5816 (2007): 1224-1225.

Toon, Owen B., Richard P. Turco, Alan Robock, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov. "Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism." *Atmospheric Chemistry and Physics* 7, no. 8 (2007): 1973-2002.

Tsadiras, Athanasios K. “Comparing the Inference Capabilities of Binary, Trivalent and Sigmoid Fuzzy Cognitive Maps.” *Information Sciences* 178, no. 20 (2008): 3880-3894.

Turco, R., O. Toon, T. Ackerman, J. Pollack, and C. Sagan. "Nuclear Winter - Global Consequences of Multiple Nuclear Explosions." *Science* 222 (1983): 1283-1292.

Turing, Alan. “On Computable Numbers, with an Application to the Entscheidungsproblem,” *Proceedings of the London Mathematical Society* 42, no. 1 (1937): 230-265.

Ulrich, Werner. “Reflective Practice in the Civil Society: The Contribution of Critically Systemic Thinking.” *Reflective Practice* 1, no. 2 (2000): 247-268.

United Nations. Office of Public Information. *Treaty on the Non-proliferation of Nuclear Weapons*. United Nations. Office of Public Information. United Nations Publication OPI/372. New York, 1969.

United Nations. “United Nations Charter, CHAPTER VII: ACTION WITH RESPECT TO THREATS TO THE PEACE, BREACHES OF THE PEACE, AND ACTS OF AGGRESSION.” 1945, http://www.un.org/en/sections/un-charter/chapter-vii/.

United States. “Effects of Limited Nuclear Warfare Hearing before the Subcommittee on Arms Control, International Organizations and Security Agreements of the Committee on

Foreign Relations, United States Senate, Ninety-fourth Congress, First Session." Washington, D.C. September 18, 1975.

United States. "*The Effects of Nuclear War*." Washington, D.C. 1979.

Vanaik, Achin and Praful Biewai. "India and Pakistan." In *Security with Nuclear Weapons?: Different Perspectives on National Security*, edited by Regina Cowen Karp. New York: Oxford University Press, 1991.

Vitali, Ali. "Trump Threatens to 'Totally Destroy' North Korea in First U.N. Speech." *NBC News*. September 21, 2017. https://www.nbcnews.com/news/us-news/trump-un-north-korean-leader-suicide-mission-n802596.

Waltz, Kenneth N. "Nuclear Myths and Political Realities," *American Political Science Review* 84, no. 3 (1990): 731-745.

Waltz, Kenneth N. "Political Structures." In *Neorealism and Its Critics*, edited by Robert O. Keohane. New York: Columbia University Press, 1986.

Waltz, Kenneth N. "The Emerging Structure of International Politics." *International Security* 18, no. 2 (1993): 44-79.

Waltz, Kenneth N. "The Stability of a Bipolar World." *Daedalus* 93, no. 3 (1964): 881-909.

Waltz, Kenneth N. *Theory of International Politics*. Reading, MA: Addison-Wesley Publishing Company, 1979).

Waltz, Kenneth N. *The Spread of Nuclear Weapons: More May Be Better*. Adelphi Papers 171. London: International Institute for Strategic Studies, 1981.

Waltz, Kenneth N. "Why Iran Should Get the Bomb: Nuclear Balancing Would Mean Stability." *Foreign Affairs* 91, no. 4 (2012): 2-5.

Warrick, Joby, Ellen Nakashima, and Anna Fifield. "North Korea now making missile-ready nuclear weapons, U.S. analysts say." *The Washington Post*. August 8, 2017. https://www.washingtonpost.com/world/national-security/north-korea-now-making-missile-ready-nuclear-weapons-us-analysts-say/2017/08/08/e14b882a-7b6b-11e7-9d08-b79f191668ed_story.html?utm_term=.8d46b85aaab2.

Wellerstein, Alex. "NUKEMAP." *the College of Arts and Letters, Stevens Institute of Technology*. 2017. http://nuclearsecrecy.com/nukemap/.

Wendt, Alexander. "Constructing International Politics." *International Security* 20, no. 1 (1995): 71-81.

Wheeler, Nicholas J. “Beyond Waltz’s Nuclear World: More Trust May Be Better,” *International Relations* 23, no. 3 (2009): 428-445.

Williams, Shirley. "Multilateral Nuclear Disarmament." *Political Quarterly* 83, no. 2 (2012): 334-342.

Wolfers, Arnold. *Discord and Collaboration: Essays on International Politics*. Baltimore, Maryland: The John Hopkins Press, 1962.

Woolley, R. N. and M. Pidd. “Problem Structuring -- A Literature Review.” *The Journal of the Operational Research Society* 32, no. 3 (1981): 197-206.

Zionts, Stanley. “MCDM—If Not a Roman Numeral, Then What?,” *Interfaces* 9, no. 4 (1979): 94-101.

VITA

Ryan Nixon
Graduate Program in International Studies
Old Dominion University
Norfolk, VA 23529

Born in Richmond, VA, Ryan Nixon enlisted in the US Navy as a Cryptologic Technician (2004 – 2007) before coming to Old Dominion University to pursue undergraduate studies in Political Science. Receiving his BA in 2012, Ryan pursued his MA (2014) before ultimately pursuing PhD studies beginning in 2015. During his tenure as a PhD student, Ryan served as a Graduate Research Assistant, a Graduate Teaching Assistant, and, ultimately, the instructor of record for two undergraduate Political Science courses. He also served as the Marketing Coordinator for the Graduate Society in International Studies (2016 – 2017). He has previously worked for NGOs, including People for the Ethical Treatment of Animals, as well as a Member of the Board of Directors of Virginians for Alternatives to the Death Penalty.

In 2018 Ryan won a prestigious Department of Energy internship with Brookhaven National Laboratory's Nonproliferation and National Security department under the mentorship of Kate Bachner, which resulted in a paper titled, "Exploring the Nuclear Safeguards Environment Using Fuzzy Cognitive Mapping."