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Governing Insecurity: Institutional Design, Compliance, and Arms Control

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Governing Insecurity: Institutional Design, Compliance, and Arms Control

by

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Professor Vinod K. Aggarwal, Chair
Professor Ron E. Hassner
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Abstract

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Governing Insecurity examines the various efforts to regulate, constrain, or ban military technology. In the process, it outlines the considerable variation in both the design of these frameworks and in compliance outcomes that existing theoretical work fails to explain. In this dissertation project, I present an original Arms Control Design Dataset (ACDD) to provide new data and methods to quantitatively assess the design features of arms control regimes and their effect upon state behavior—specifically compliance. I focus this analysis on agreement type, membership, type of verification regime, and the decision to include sunset provisions in four quantitative chapters. The dissertation concludes by considering the lessons learned from this analysis for future efforts to regulate military technologies.

For my family

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Part I

A Framework for Analysis

Chapter 1

Towards a Scientific Study of Arms Control

Debs and Monteiro note in their 2016 volume that "the history of international politics since 1945 is to a great extent the history of nuclear politics."[1] This history encapsulates many of the theoretical debates between scholars of international relations—whether concerning the effects of polarity on the international system, alliance dynamics, and the foreign policy prerogatives of great powers. Beyond the competitive dynamics that are often associated with scholarship on nuclear deterrence, however, nuclear politics have also provided a venue for international cooperation. This project seeks to shed light on the oft-ignored practice of cooperation in the nuclear era, in general, and the practice of arms control, in particular. Specifically, I argue that the institutional design of arms control regimes both reflect and shape nuclear politics and explain two phenomena of particular interest to scholars of international relations: first, the considerable variation in the design of international institutions and, second, the considerable variation in the outcomes—or performance—of international institutions.[2]

1.1 Introduction

In a 1960 *Daedulus* article following the publication of his most famous work, *The Strategy of Conflict*, Thomas Schelling turns to the question of arms control.[3] In the article, he poses a series of rhetorical questions to policy-makers:

> Do we wish the hydrogen bomb had never come along to make intercontinental missiles economical? Do we wish that nuclear-powered aircraft had made airborne

[1] Alexandre Debs and Nuno P Monteiro, *Nuclear Politics*, vol. 142 (Cambridge University Press, 2016).

[2] Ranjit Lall, "Beyond institutional design: Explaining the performance of international organizations," *International Organization* 71, no. 2 (2017): 245–280; Tamar Gutner and Alexander Thompson, "The Politics of IO Performance: A Framework," . *The Review of International Organizations* 5, no. 3 (2010): 227–248.

[3] Thomas C Schelling, "Reciprocal measures for arms stabilization," *Daedalus* 134, no. 4 (2005): 101–117.

> alert so cheap that retaliatory aircraft could stay aloft rather than be vulnerable on the ground to a missile attack? Do we hope that no one ever discovers an economical means of nullifying ballistic-missile submarines, so that neither side can hope to preclude retaliation by sudden attack? Do we wish that warning systems were so nearly perfect that "false alarm" were virtually impossible, or so poor that we could never be tempted to rely on them? Do we wish that missiles had never become so accurate that they could be used to destroy an enemy's missiles in an effort to negate an enemy's retaliatory threat? Do we wish that radioactive fallout could not occur, or do we welcome it as a peculiarly retaliatory (and hence deterrent) weapon effect that is of little use in a pre-emptive attack? Do we wish that secrecy about weapons and weapon production were much more difficult to maintain than it is, or welcome certain kinds of secrecy as a form of mutually appreciated security against surprise attack?

In pursuit of "international order, "strategic stability," and to arrest "arms racing behavior" the answers to these questions have often been yes. However, while the question of "how" to achieve arms control remains central for policy-makers, academics have largely eschewed a scientific study of arms control. Writing in 1972, Chayes argues that "the literature of arms control is singularly barren on the question of how a treaty or agreement actually affects the behavior of states."[4] Today, we are little closer to building theory surrounding the consequences of arms control and existing scholarship has hitherto failed to assess these arrangements and their impact on arms racing behavior, instead relying explanations that privilege norms, domestic politics, and great power politics to explain changes in state behavior. This dissertation project, drawing on both quantitative and qualitative methods to examine a utilitarian theory of arms control design seeks to remedy this gap in the literature by considering the effects of institutional design upon compliance.

Given contemporary noncompliance issues concerning arms control, this is a particularly important topic. Russian noncompliance with the Intermediate-Range Nuclear Forces (INF) Treaty, Syrian noncompliance with the Chemical Weapons Convention, Iran's recent abrogation of the Joint Comprehensive Plan of Action (JCPOA) following U.S. withdrawal, and North Korea's sustained noncompliance with multiple U.N. Security Council resolutions concerning the most dangerous of military technologies, nuclear arms, justify the renewed focus on arms control and demonstrate the need for renewed academic attention and the use of new methods of inquiry.

In this introductory chapter, I outline the challenges faced in the contemporary arms control regime, discuss the genealogy of arms control, and provide a brief history of arms control before briefly introducing the project and the chapters to follow.

[4] Abram Chayes, "An inquiry into the workings of arms control agreements," *Harvard Law Review*, 1972, 905–969.

1.2 A Brief History of Arms Control

Efforts to constrain, regulate, and ban the use—and tools—of force have been around for as long as military technology itself. In the ancient world, arms control regimes focused on the disarmament of those defeated in war. The Rome-Carthage Treaty of 201BC and the Rome-Macedon Treaty of 196BC serve as historical examples of this phenomenon.[5] As noted above, the limits placed upon the German army of 100,000 men with no tanks or artillery and no air force as part of the 1919 Treaty of Versailles serve as a more recent example of "disarmament following a war."[6]

Past examples of arms control reflect the discussions of "appropriateness" noted above. During the Middle Ages, the Catholic church played a significant role in outlining the terms of warfare in Europe throughout the early 1000s.[7] In Poitiers, Limoges, and a number of other European towns from 1000 to the early 1400s, religious leaders sought to create rules that banned the practice of warfare against specific classes of people and temporally—on the Sabbath.[8] In 1139, Canon 29 of the Second Lateran Council banned the use of crossbows against Christians and Catholics—an early documented example of banning particular classes of weapons. In an example of 12th century export control, Canon 71 of the Fourth Lateran Council banned weapons transfer to the non-Christian Saracens.[9] These historical cases of disarmament provisions, constraints on weapon use, and prohibitions of technology transfer are, incidentally, broadly representative of contemporary regulatory mechanisms used to regulate military technology—whether concerning nuclear weapons, capital ships, or small arms.

In the past seven decades and with the advent of weapons with strategic (that is, existential) effects, efforts to control arms have arguably become increasingly salient: "[While] the impulse to control and regulate the instruments of war is nearly as old as war itself... the advent of nuclear weapons gave the enterprise new urgency."[10] This urgency led to early efforts in the late 1940s and early 1950s to assure international control of nuclear technology via the U.S.-led Baruch Plan that called for states to eschew the development of nuclear weapons and submit to international inspections of sites engaged in nuclear weapon development and testing. While this Plan did not succeed, governments later signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968 aimed to prevent the proliferation of nuclear weapons beyond those states that had achieved a nuclear test by the signatory date—the United States, Russia, United Kingdom, France, and China. The NPT—via Article VI—also called for progress on the disarmament of all nuclear states.[11] This new

[5]Stuart Croft, *Strategies of arms control: a history and typology* (Manchester University Press, 1996).

[6]Jozef Goldblat, *Arms control: a survey and appraisal of multilateral agreements* (Taylor & Francis Ltd, 1978).

[7]Stefan T Possony, "Peace enforcement," *The Yale Law Journal* 55, no. 5 (1946): 910–949.

[8]The church would eventually allow fighting on Mondays, Tuesdays, Wednesdays, and Thursdays with protections for "clerics, nuns, pilgrims, women, children, and workers."

[9]Croft, *Strategies of arms control: a history and typology.*

[10]Avis Bohlen, "The rise and fall of arms control," *Survival* 45, no. 3 (2003): 7–34.

[11]The NPTs third pillar allows for the peaceful use of nuclear technology by all states—and has led to a

category of strategic weapons directly led to a majority of the arms control frameworks in force today. These arms control agreements involving the United States and the USSR (later Russia) include those concerning the use, stockpiling, and eradication of classes of nuclear warheads, delivery vehicles including SALT I and START I, and weapon systems designed to destroy them—such as anti-ballistic missiles previously controlled by the Anti-Ballistic Missile (ABM) Treaty.

Whether these past examples of arms control will condition contemporary arms control remains an open question.

1.2.1 Arms Control in the 21st Century

The Intermediate-range Nuclear Forces Treaty noted above was signed in 1987 by the United States and USSR and is designed to ban ground-launched ballistic and cruise missiles with a range of between 500 and 5,500 kilometers. It, along with START I and the CFE Treaty represented the high-water mark of arms control agreements involving the two great powers of the period. In July 2014, however, the United States accused Russia of developing intermediate-range missiles in violation of its Treaty violations. This allegation was later made specific—the United States objected to Russia's development of the SSC-X-8 (9M729) Iskander-K ground-launched cruise missile system. Russia, in turn, accused the United States of violating the same treaty by deploying missile defense systems in Eastern Europe. As of July 2019, the INF Treaty's Special Verification Commission created "to resolve questions relating to compliance with the obligations assumed" had failed to address the abrogation of the treaty—calling into question the renewal of New START in 2021 and the future of arms control negotiations between the two states.

Non-nuclear accords have also been under threat. The Chemical Weapons Convention (CWC)—a universal rather than bilateral regime—designed to arrest the production, stockpiling, and use of chemical weapons played by a limited role in responding to Syria's use of chemical weapons in Homs, Aleppo, and Douma in the course of its civil war. The failure to enforce this arms control agreement was compounded by an attack involving a nerve agent (Novichok, A-234) on Sergei Skripal and his daughter in Salisbury on March 4, 2018.

While states have failed to comply with both nuclear and non-nuclear arms control agreements, efforts to address emerging technologies including hypersonic missiles, space-based weapons, cyber weapons, and lethal autonomous weapons (LAWS) have largely stalled in a series of UN Group of Government Experts (GGE) processes.[12]

Overall, this does not present an auspicious report on the current status of arms control as we enter what the 2018 U.S. National Defense Strategy describes as a "re-emergence of long-term strategic competition." As current arms control frameworks wane and others

number of nuclear cooperation agreements between states. Incidentally, the NPT is a singularly interesting international agreement as it reifies sovereign inequality among states by separating the nuclear "haves" from the "have nots."

[12]Denise Garcia, "Future arms, technologies, and international law: Preventive security governance," *European Journal of International Security* 1, no. 1 (2016): 94–111.

are being negotiatied, I argue that this is an appropriate historical moment in which to empirically examine the historical record concerning the consequences of arms control both to understand contemporary policy challenges but also to understand a form of international cooperation that scholars often overlook—despite their representing a singularly hard bargain for states to strike. To some extent, the richness in the design of arms control reflects this difficulty in striking lasting bargains that impinge on the development of national armed forces.

Among the over two hundred frameworks designed to regulate, constrain, or ban military technology, there is considerable variation in their design—and particularly in terms of their scope, membership, flexibility, and enforcement mechanisms. The consequences of this variation, however, remain largely under-explored. Scholars have only recently started considering the implications of intergovernmental arms control agreements—and these have predominantly focused upon the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and its associated impact on nuclear proliferation.[13] In answer to Fuhrmann and Lupus query "do arms control treaties work?" The answer thus far appears to be yes—at least with regard to the NPT. But does this finding travel? And what causes it? Is the finding explained by the underlying technology being regulated or the specific institutional architecture deployed around the NPT?

Fuhrmann and Lupu's finding is in line with a broader contention put forward by Chayes and Chayes that international agreements alter state behavior and expectations of states parties in accordance with the terms of the agreement.[14] *How* international institutions achieve this effect, however, remains ripe for further examination. Given the substantial variation in the design of arms control agreements in terms of their membership, design, and rules, I posit in this dissertation that scholars of institutional design have an important role to play in considering the mechanisms through which international regimes constrain state behavior.

To that end, I provide a conceptual framework surrounding arms control in the next section before turning to a brief history of arms control.

1.3 What is *Arms Control*?

Arms control has been explored by historians, political scientists, anthropologists, and in the retrospective accounts of past arms control negotiators. In these accounts, there are two

[13]Matthew Fuhrmann and Yonatan Lupu, "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty," *International Studies Quarterly* 60, no. 3 (2016): 530–539; Sonali Singh and Christopher R Way, "The correlates of nuclear proliferation: A quantitative test," *Journal of Conflict Resolution* 48, no. 6 (2004): 859–885; Beth A Simmons and Daniel J Hopkins, "The constraining power of international treaties: Theory and methods," *American Political Science Review* 99, no. 4 (2005): 623–631.

[14]Abram Chayes and Antonia Handler Chayes, "On compliance," *International Organization* 47, no. 2 (1993): 175–205; Abram Chayes and Antonia Handler Chayes, "Compliance without enforcement: state behavior under regulatory treaties," *Negotiation Journal* 7, no. 3 (1991): 311–330.

competing narratives concerning intergovernmental efforts to regulate military technologies: those of disarmament and arms control.

The disarmament narrative places arms control, in its various guises, within a discussion concerning the (in)appropriateness of a particular weapon's development, deployment, and use. Often, this narrative notes the norms and taboos that led to the prohibition or restricted the terms of use for specific categories of weapons—with subsequent consequences on the intensity of conflict or the "destructiveness of war." Recent debates surrounding the regulation of lethal autonomous weapons (LAWS) and efforts to make sure that a "human is in the loop" of weapons that might otherwise be autonomous reflect an interesting development of this perspective as it engages with the question of "who" or "what" is allowed to kill in war.[15]

Others suggest that arms control, rather than representing the "(in)appropriateness" of methods of warfare, remains part of a broader "strategic" competition among states. This narrative considers three aspects of arms control that influence the competitive dynamics between states. I highlight each below.

First, the avoidance of opportunity costs associated with developing particular military technologies.[16] These opportunity costs vary based on the military technology but, as Schelling and Halperin point out, avoiding "tit for tat" military spending offered an important benefit of arms control. Second, while not all arms control agreements are reciprocal or symmetrical—with the Washington Naval Treaty offering a prototypical example of an asymmetrical agreement—arms control agreements can also be used to reinforce a balance of forces between adversaries in both a regional and global context.[17] Third, arms control negotiators point to the "stability enhancing" processes of arms control regimes. Past negotiators in Washington noted, for example, the benefits of information exchanges and on-site inspections that are often included as enforcement mechanisms in arms control agreements for confirming intelligence gathered from other sources.

I argue in the dissertation to follow that this process-oriented conceptualization of arms control best explains the variation in the institutional design and the consequences of arms control regimes over time by pointing out, in simplest terms, that design matters.

[15]John Lewis, "The case for regulating fully autonomous weapons," *Yale LJ* 124 (2014): 1309; Jurgen Altmann and Frank Sauer, "Autonomous weapon systems and strategic stability," *Survival* 59, no. 5 (2017): 117–142; Michael C Horowitz, "When Speed Kills: Autonomous Weapon Systems, Deterrence, and Stability," *Deterrence and Stability*, 2019, Incidentally, there are already a number of military technologies that leverage automation in which humans are, in fact, fully "out of the loop." For further details, see:Vincent Boulanin, *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk*, technical report (SIPRI, 2019).

[16]Thomas C Schelling and Morton H Halperin, "Strategy and Arms Control," *Twentieth Century Fund*, 1961,

[17]The CFE Treaty offers an example of a regional arms control framework designed to maintain relative parity between NATO and Warsaw Pact states at the end of the Cold War. The series of strategic arms limitation agreements involving the United States and the USSR (and, latterly, Russia) offer examples of agreements designed to maintain a global balance of forces using symmetrical nuclear warheads numbers (though asymmetric deployments using different types of delivery vehicles).

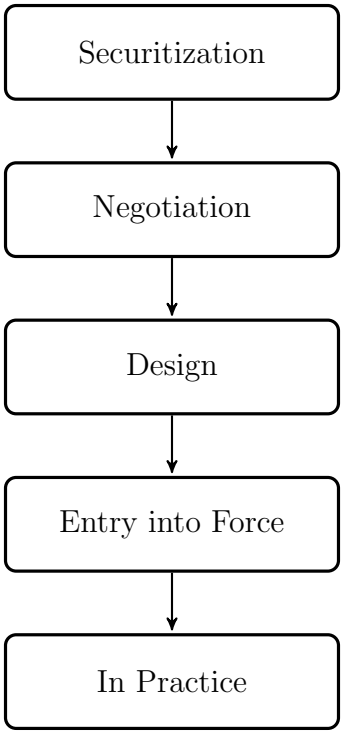

Figure 1.1: This figure summarizes the stages of arms control as a process

1.4 Arms Control as a Process

In the section below, I outline the necessary conditions associated with producing arms control. This involves the securitization of a specific technology by a state or states, the entry of states parties into negotiation to bargain over the type and design of arms control, an agreement's entry into force (usually via domestic politics, and, finally, the practice of arms control.[18]

1.4.1 "Securitization"

In this section, I outline the process of "securitization" through which a state perceives and acts on a security-related use for a given technology.[19] In the process, the technology is "securitized" during the research and development or prototype phase.

There are a series of constructivist innovations that ground the concept of security that

[18]The process of arms control, like many other international processes, reflects the variety of disciplines that might be used to understand it—from domestic politics-focused analyses of ratification processes to analyses that privilege the challenges of inter-state bargaining under conditions of anarchy.

[19]Of course, the very development of technology is not exogenous, with governments often playing a key role in developing new technology via industrial policy as well as indirect and direct investment.

might be useful for considering how states choose to "securitize" a specific technology.[20] In simple terms, securitization constitutes a "speech act"—a political process—by an actor with political power. This speech act "securitizes an issue space, technology, or actor.[21] Some recent examples of securitization concerning technology include nanotechnology and supercomputing resources associated with new types of machine learning (often referred to as "artificial intelligence"). When considering the process through which states identify technologies—from advances in nuclear physics to genetic engineering—we might examine the state-based decision-making processes that underpin this speech act in terms of a rational calculation of the potential benefits and risks posed by the technology. As Roberts noted in 1993, "little research attention has been given to the diffusion of the scientific and technological foundation upon which these military capabilities must rest: for example, expertise in computer-aided design and manufacturing techniques, microelectronics, aeronautics, computer engineering, advanced materials development, and precision machining.[22]

Kroenig and Volpes work on 3-D printing is also illustrative here.[23] 3-D printing is not a weapon per se, but is an innovative method through which a complex weapon technology—in their article, a nuclear bomb—might be manufactured with lower barriers to entry than is traditionally the case. At the same time, there are a series of economic uses for 3-D printing that are likely to become more difficult in the event that the technology is "securitized"—that is constrained, classified, and subject to export control and trade restrictions. Indeed, policymakers are continually weighing the costs and benefits of securitization. These costs and benefits are driven by domestic political considerations as well as the perceived opportunities for the state and threats to the state from adversary use of a particular technology.[24] The latter might also be described as representing uncertainties over preferences and the behavior of other states as well as uncertainty about the state of the world into which the technology represents an exogenous shock to the extant order.[25]

Future work might consider the pathways of securitization prior to a technology's deployment. For my purposes, however, it is most important to note that the decision to regulate a military technology is taken *prior* to the intergovernmental negotiations that shape arms control—the practice of which is the subject of this dissertation.

[20]Filippa Lentzos and Nikolas Rose, "Governing insecurity: contingency planning, protection, resilience," *Economy and Society* 38, no. 2 (2009): 230–254.

[21]O. Waever, "Securitization and desecuritization," in *On security* (Columbia University Press, 1995).

[22]Brad Roberts, "From nonproliferation to antiproliferation," *International Security* 18, no. 1 (1993): 139–173.

[23]Matthew Kroenig and Tristan Volpe, "3-D printing the bomb? The nuclear nonproliferation challenge," *The Washington Quarterly* 38, no. 3 (2015): 7–19.

[24]The state often remains a unitary actor in these analyses but it is worth noting that there are a number of constituencies associated with decisions to regulate technologies—not least the private sector that often attempts to shape the regulatory preferences of their respective governments and, occasionally, international actors.

[25]This approach mirrors Putnams work on two-level games.Robert D Putnam, "Diplomacy and domestic politics: the logic of two-level games," *International organization* 42, no. 3 (1988): 427–460.

1.4.2 Arms Control Negotiations

Following securitization, governments face a question: Are domestic regulatory arrangements appropriate/adequate for addressing the security challenge posed by the technology? If not, are intergovernmental negotiations necessary and/or desirable?

In a case in which domestic regulation is adequate, intergovernmental arrangements are rarely used beyond efforts to harmonize regulations across countries (serving to establish best practices and lessen transaction costs for private firms). In the latter case, the first question facing policy-makers is *what* to control. While this may sound simple in theory, it is often difficult in practice with states disagreeing over whether particular technologies or uses of a technology should be the subject of an arms control agreement both prior to and during arms control negotiations.[26] This difficulty is explained by the stakes of arms control used to address some of the most destructive, expensive, and consequential military technologies ever created—not least nuclear weapons. According to past arms control negotiators, the debates concerning the definition of types of nuclear warhead and categories of delivery vehicles in the START framework or those chemical precursors that should be included in Schedule 2 by the OPCW are as contentious as the design of the regime designed to regulate them.

Upon deciding *what* is regulated, states face a second challenge: negotiations concerning *how* to control the technology. This challenge is, in my estimation, reflected in the institutional design decisions undertaken by states during the negotiation process and represents a central focus of this dissertation project.

1.4.3 Design

Upon agreeing that a military technology requires intergovernmental regulation, arms control negotiators have a number of options at their disposal concerning *how* the technology may be regulated. These options stem both from past examples of arms control as well as being conditioned by the type of military technology in question, the past experience of arms control negotiators, as well as the state's force posture. In discussions with those in the room during the negotiations of SALT, CFE, START, and New START, a number of negotiators noted the importance and use of heuristic devices on the part of arms control negotiators to overcome negotiating challenges and arrive at policy solutions that each side could live with.[27] These design considerations present a rich source of variation between different types of arms control agreements. This variation, as briefly noted above, can be viewed across a number of institutional design parameters including the scope and membership of an arms control regime, the types of enforcement mechanisms employed to monitor an agreement, and the length of the agreement. Each of these design parameters are explored in stand-

[26]Sarah Elizabeth Kreps and Anthony Clark Arend, "Why States Follow the Rules: Toward a Positional Theory of Adherence to International Legal Regimes," *Duke J. Comp. & Int'l L.* 16 (2006): 331.

[27]Often, members of the negotiations spoke glowingly of the leadership provided by the Heads of Delegation to each of the negotiations.

alone chapters of this dissertation to follow. [28] It is worth noting that in practice arms control negotiations rarely take place in one room. Rather, representatives of states parties are usually dispersed across a number of locations in which they are empowered to represent their respective government on particular issues—whether the definitions of key provisions in the Treaty, technical verification measures to be included in the Treaty, or the reporting obligations to be included in the Treaty. The number of meetings and rounds of talks also vary from one arms control regime to another.

In both the negotiation and institutional design conversations, political considerations external to discussions between states parties also lurk in the background. In the United States, for example, the inter-agency involving relevant Cabinet departments and Congressional delegations play a central role in shaping U.S. negotiation priorities. Upon successful negotiations, these political considerations external to the negotiations themselves become central as states parties decide whether to sign and subsequently ratify an agreement prior to its entry into force.

1.4.4 Entry into Force

Generally speaking, states—partiuclarly in bilateral contexts—do not conclude negotiations until it is clear that the agreement will be signed by their respective executives and ratified by their constituents to enter into force. In multilateral contexts, this is complicated by the fact that a subset of states can conclude and sign an agreement without consensus. Upon signature, international agreements are subject to ratification procedures that vary by state—but that nominally involve a process informed by domestic politics. In Russia, for example, the Duma ratifies arms control agreements while in the United States the Senate is given this responsibility. Recent work from Kreps, Saunders, and Schultz examines the challenge associated with ratification process by identifying a credibility gap facing dovish (generally, Democratic) Presidents (described as a "ratification premium") that complicates their efforts to achieve arms reduction via ratification by Congress.[29]

Following the ratification of an agreement, an agreement's entry into force is contingent upon a period following the signature and ratification of the agreement by all or a subset of state parties or on a specific date specified by the Treaty. Article XIV of the Comprehensive Test Ban Treaty, for example, notes that the Treaty will enter into force 180 days after the last of the 44 states included in Annex 2 of the agreement deposits its instruments of ratification. Of these states, China, Egypt, Iran, Israel, and the United States, have signed

[28] In this project, I focus primarily on nuclear military technologies—with existential consequences—and those agreements that primarily concern the regulation of these technologies, but there are also a number of arms control components included within broader international agreements. The Treaty of Versailles, for example, includes an arms control component in calling for the disarmament of Germany. More recent agreements to end civil conflicts—such as the Dayton Accords to address civil war in the former Yugoslavia—also arguably include arms control components related to the disarmament of former combatants.

[29] Sarah E Kreps, Elizabeth N Saunders, and Kenneth A Schultz, "The Ratification Premium: Hawks, Doves, and Arms Control," *World Politics* 70, no. 4 (2018): 479–514.

but not ratified the Treaty while North Korea, India, and Pakistan have not signed the Treaty—thus the Treaty has not yet entered into force.

There are also numerous historical examples of arms control agreements that upon signature have not been ratified, including SALT II which was signed by both parties following ten years of negotiations but that upon the outbreak of the USSR-Afghan War, the United States decided not to ratify. The USSR, in turn, did not ratify the Treaty. The Arms Trade Treaty, signed by the United States in 2013 and awaiting ratification offers a more recent example.

1.4.5 Arms Control in Practice

For those agreements that enter into force, they become examples of arms control in practice—with some requiring annual reporting of data to states parties, hosting a prescribed number of inspections, or taking part in intergovernmental organizations. The practice of arms control also involves making decisions concerning whether to comply with an arms control obligation, or not. There are, as I note in the following chapters, varying types of provisions included in agreements to monitor and enforce arms control agreements including information exchanges and on-site inspections as well as a number of ad hoc and intergovernmental organizations that support arms control agreements that states sign up to—as described in greater detail in Chapter 5. These mechanisms, I argue, affect decisions to continue to comply with an agreement and eschew the development and deployment of specific military technologies, or not.

Having outlined the process of arms control, I now turn to existing work concerning the regulation of military technology.

1.5 Understanding Arms Control

Scholars of international security have long attempted to determine the effects of technology upon international relations. This effort has hitherto led to two avenues of research. The first led scholars to consider the effects of technology upon the stability in the international system. Van Evera and others came to the argument that "offensive" weapons were destabilizing while, conversely, "defensive" weapons were stabilizing.[30] In recent years, however, the thesis that technology plays an exogenous role in determining stability has been called into question with a number of scholars noting the need for further research regarding the mechanisms through which technology impacts state behavior.[31]

[30]Stephen Van Evera, "The cult of the offensive and the origins of the First World War," *International Security* 9, no. 1 (1984): 58–107; Stephen Van Evera, "Offense, defense, and the causes of war," *International Security* 22, no. 4 (1998): 5–43; Charles L Glaser and Chairn Kaufmann, "What is the offense-defense balance and how can we measure it?," *International security* 22, no. 4 (1998): 44–82.

[31]Keir A Lieber and Daryl G Press, "The new era of counterforce: Technological change and the future of nuclear deterrence," *International Security* 41, no. 4 (2017): 9–49; Ryan Snyder et al., "Correspondence:

A second avenue of research focuses on the impact of nuclear weapons upon international affairs and arms control against the backdrop of nuclear deterrence. Indeed, much as been made of the effects of nuclear technology, the doctrine of mutually assured destruction, and second-strike capabilities and their associated impact upon strategic stability.[32] Even as the Cold War ended, nuclear weapons have remained central to discussions in security studies—even if most of this discussion has centered on the proliferation of nuclear weapons and their role in inter-state competition.[33] Academic engagement on the question of cooperation in the shadow of nuclear politics is altogether more limited.[34]

In one of the best recent examples engaging with arms control, "Do arms control treaties work?," Fuhrmann and Lupu focus exclusively on examining the effect of a nuclear treaty, the NPT.[35] Other treaties, however, are left out of the analysis and which aspects of the treaty are "working" remains an open question. There is also a danger that in focusing exclusively on agreements that seek to limit proliferation or the numbers of nuclear weapons, the literature fails to account for secondary technologies that share strategic consequences. Roberts, for example, notes that "in neither government nor academe does one find a sense of how the new strategic environment has redefined what responses to proliferation are both necessary and possible, or a concept of how these pieces of the puzzle fit together. The result is an emphasis on fine-tuning old approaches, a tendency to apply outdated conceptual models to new challenges, and disarray in policy."[36] This research project represents a small effort to address these concerns by investigating a larger number of empirical cases and to consider how the variation in the institutional design of arms control agreements affect compliance outcomes.

The dissertation to follow offers a renewed consideration of arms control regimes across a variety of military technologies using both quantitative and qualitative insights to consider the lessons learned from the past seventy years of efforts to constrain the development and

New Era or New Error? Technology and the Future of Deterrence," *International Security* 43, no. 3 (2019): 190–193.

[32]Bernard Brodie, "Nuclear weapons: strategic or tactical?," *Foreign Affairs* 32, no. 2 (1954): 217–229; Schelling and Halperin, "Strategy and Arms Control"; Francis J Gavin, "Same As It Ever Was: Nuclear Alarmism, Proliferation, and the Cold War," *International Security* 34, no. 3 (2010): 7–37; Kenneth N Waltz, "Why Iran should get the bomb: Nuclear balancing would mean stability," *Foreign Affairs* 91 (2012); Debs and Monteiro, *Nuclear Politics*.

[33]Erik Gartzke and Matthew Kroenig, "Social Scientific Analysis of Nuclear Weapons: Past Scholarly Successes, Contemporary Challenges, and Future Research Opportunities," *Journal of Conflict Resolution* 61, no. 9 (2017): 1853–1874.

[34]Steve Weber, *Cooperation and discord in US-Soviet arms control*, vol. 166 (Princeton University Press, 1992). For recent work in this space, see: Jane Eugenia Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries" (PhD diss., Cornell University, 2014); Sarah E Kreps, "The institutional design of arms control agreements," *Foreign Policy Analysis* 14, no. 1 (2018): 127–147; Fuhrmann and Lupu, "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty."

[35]Fuhrmann and Lupu, "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty."

[36]Roberts, "From nonproliferation to antiproliferation."

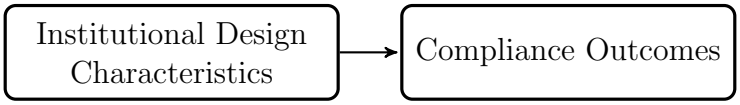

Figure 1.2: This figure shows the basic argument of the dissertation to follow.

deployment of strategic weapons.

1.6 Research Question

In simplest terms, this dissertation considers one central question:

- What are the variable effects of design parameters used in arms control frameworks on compliance?

In the process, I make a series of choices concerning those institutional design parameters representing the independent variable that are of theoretical interest (and that reflect existing scholarship concerning institutional design). I also argue that a primary dependent variable of interest in terms of arms control agreement outcomes is compliance—given that states that negotiate, sign, and ratify agreements might be reasonably expected to abide by the terms of the agreement and when they fail to do so, this represents an interesting empirical puzzle for analysis. In the section below, I discuss compliance and the institutional design parameters that are the subject of this dissertation and provide brief definitions that are subsequently used to code the Arms Control Design Dataset (ACDD). Both concepts are explored in greater detail in the chapters to follow.

1.6.1 The Dependent Variable: Compliance

There are, of course, a variety of outcome variables that might be of interest to scholars of arms control. These include the status of weapon proliferation (the number of weapons developed, deployed, and used), patterns of state power, and instances of inter-state disputes. This line of inquiry might, for example, allow scholars to consider what the marginal effect of employing arms control with stringent verification regimes are on global arms numbers. While these alternative outcome variables are no doubt of interest and may be the focus of future work, in this project I examine compliance as the outcome variable of primary interest.

How and why states comply with their international obligations has long presented in a puzzle to scholars of international relations—particularly when these obligations are in tensions with their perceived national interest. While some argue that international institutions shape compliance preferences, others argue that the design of international institutions

shape compliance outcomes.[37] As noted above, much of the existing literature has focused on environmental and economic institutions rather than security regimes.[38] To some extent, this is explained by non-security domains offering a comparatively rich empirical record from which to garner insights. The major problem with basing our understanding of compliance from this limited set of empirical cases, however, is that the dynamics of international cooperation may be entirely different in non-security domains. This distinction between "high politics" involving security concerns and "low politics" involving economic policy has been made elsewhere in the international relations canon.

In this project, I examine instances of compliance and non-compliance in the context of nuclear arms control—in which states face security-related trade-offs and opportunity costs as they make decisions that affect their respective military capabilities.[39] While episodes of compliance and non-compliance are discussed in greater depth in Chapter 3, it is worth noting that there are a number of instances in which states have alleged that others are in non-compliance or have made the decision to no longer comply with the obligations of an arms control agreement. The Partial Test Ban Treaty, ABM Treaty, Nuclear Nonproliferation Treaty, and INF Treaty each represent agreements that have, variously, faced compliance challenges during their existence. Within the Arms Control Design Dataset, I define compliance and non-compliance as follows: When all states parties in an agreement abide by the terms of the agreement in a given agreement-year or country-agreement-year, it is coded as compliant. If a state party to an agreement fails to abide by the terms of a treaty, then it is coded as non-compliant. The dataset itself relies on academic, historical, and journalistic sources to make a determination of compliance in each instance.[40]

Now, I turn to the institutional design parameters that are theorized to affect compliance outcomes in the context of arms control.

1.6.2 The Independent Variable: Institutional Design

In this section, I outline the institutional design parameters theorized to affect compliance outcomes. In the process, I draw on a rich literature concerning the effects of institutional design on international relations.[41] These design choices include decisions concerning the for-

[37]For an argument of the former, see Chayes and Chayes, "On compliance"; Chayes and Chayes, "Compliance without enforcement: state behavior under regulatory treaties." On the latter, see Carmela Lutmar, Cristiane L Carneiro, and Sara McLaughlin Mitchell, *Formal commitments and states' interests: Compliance in international relations* (Taylor & Francis, 2016).

[38]See Aakre et al. (2016) for a recent example of work examining compliance in the context of climate change: Stine Aakre, Leif Helland, and Jon Hovi, "When does informal enforcement work?," *Journal of Conflict Resolution* 60, no. 7 (2016): 1312–1340.

[39]In future work, the ACDD will be broadened to include non-nuclear cases. For now, nuclear cases both serve as cases of arms control for which we have historical accounts and empirical data while also offering the opportunity to, as best we can, compare apples to apples.

[40]These choices and all of the episodes of non-compliance included in the ACDD are discussed in Chapter 3.

[41]Vinod K Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting* (Cornell University Press, 1998); Barbara Koremenos, "Loosening the ties that bind: A learning model of agreement

malization, centralization, flexibility, rules, strength, scope, and membership of a regulatory regime, as well as decisions to include verification mechanisms in the regulatory framework and how each design consideration shapes state behavior.

As is the case with the compliance literature, much of the empirical and theoretical work concerning institutional design focuses on non-security cases. Given the existing research concerning institutional design in non-security settings, however, there is good reason to believe differences in design matter and may shape agreement outcomes.[42] With that said, how variation in design characteristics of international regimes impact agreement outcomes remains under-specified in the broader international political economy literature, in general, and in the arms control literature, specifically.

Fortunately or unfortunately, arms control represents a series of "hard cases" for international cooperation when compared to economic and environmental regimes given the sovereignty costs associated with cooperating with the agreement and the existential consequences for the state that complies with an agreement while another does not. As Keohane notes in his 1990 treatise on multilateralism, "to investigate the impact of institutions on interests, one possible approach is to identify the situations in which institutional rules are "inconvenient": that is, in which they conflict with governments' perceptions of what their self interests would be if there were no such institutions."[43] Taking weapon systems off of the table and making missile fabrication facilities available to inspectors represent examples of such an inconvenience, though the word may downplay its seriousness.

In the chapters to follow, I focus on four specific institutional design characteristics.

First, I examine how the scope (or type) of an agreement might shape compliance outcomes. In the process, I compare patterns of compliance and non-compliance among agreements designed to *prohibit* the development and deployment of nuclear weapons, agreements designed to *limit* the development and deployment of nuclear weapons, agreements designed to *ban testing* of nuclear weapons, and softer agreements that *control* nuclear technology for the purposes of nuclear risk reduction. In the analysis, I find that agreements that are more ambitious in terms of constraining state behavior are at increasing risk of non-compliance.

Second, I examine how varying types of verification regimes shape patterns of compliance to test whether the conventional wisdom that stringent and intrusive verification regimes are desirable. In the process, I also consider the variation in the types of institutions charged with monitoring arms control regimes. An analysis of the empirical record suggests that the

flexibility," *International Organization* 55, no. 2 (2001): 289–325; Kenneth W Abbott and Duncan Snidal, "Hard and soft law in international governance," *International Organization* 54, no. 3 (2000): 421–456; Felicity Vabulas and Duncan Snidal, "Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements," *The Review of International Organizations* 8, no. 2 (1990): 193–220; Walter Mattli and Ngaire Woods, *The politics of global regulation* (Princeton University Press, 2009); Joseph Jupille et al., *Institutional choice and global commerce* (Cambridge University Press, 2013).

[42]Ronald B Mitchell, "Regime design matters: intentional oil pollution and treaty compliance," *International Organization* 48, no. 3 (1994): 425–458.

[43]Robert O Keohane, "Multilateralism: an agenda for research," *International Journal* 45, no. 4 (1990): 731–764.

most intrusive types of verification are not, as is currently believed, more likely to lead to compliance.

Third, I compare those agreements that are designed to last in perpetuity to those agreements that include a termination clause after a specific period of time. Interestingly, those agreements that have termination clauses perform better than those that are designed to last of indefinite duration.

Finally, I analyze how the membership of an agreement affects compliance outcomes. While there is disagreement in the existing literature over the relative benefits of bilateral, minilateral, and multilateral frameworks, the analysis of existing arms control agreements suggests membership may matter less than currently believed.

Each of these institutional design variables are considered in their own respective chapter, outlined in the section below while I also engage with prior treatments of the institutional design of arms control that account for the delegation, obligation, and precision of an agreement and consider the systemic context in which agreements are complied with by testing for Cold War effects and the fact that a number of arms control agreements build upon one another.[44]

1.7 Chapter Outline

In the following two chapters, I outline a "Framework for Analysis." In it, I examine the existing academic literature pertaining to compliance and institutional design before outlining the research design and quantitative methods used throughout the dissertation project. In the second "Analysis" section of the dissertation, I analyze the effects of arms control upon state behavior and pay particular attention to the four institutional design variables noted above. The final chapters of the dissertation examine a series of contemporary cases of arms control while reflecting on the findings of the dissertation both for our scholarly understanding of arms control as well as international cooperation. I then discuss how these findings may be salient in discussions of what arms control agreements ought to look like in the 21st century.

[44]Kreps and Arend, "Why States Follow the Rules: Toward a Positional Theory of Adherence to International Legal Regimes."

Chapter 2

Institutional Design in Theory

Abstract

In this chapter, I examine existing theoretical scholarship concerning how the design of international institutions affects patterns of international cooperation. First, I discuss existing theory pertaining to compliance before turning to a series of theoretical approaches to institutional design. Finally, I conclude the chapter by pointing to the various institutional design characteristics of arms control agreements that shape state behavior—and that represent the focus of the quantitative chapters to follow.

2.1 Introduction

As noted in Chapter 1, this dissertation is concerned with how the design of arms control agreements shapes the behavior of states party to the agreement. The theoretical importance of this work is driven by two puzzles.

First, and as a number of scholars have pointed out, the design of international institutions varies from regime to regime. A number of institutions, like the NPT for example, place binding commitments on states parties and involve a formal institution to monitor these commitments. At the same time, states also use informal, ad hoc arrangements to address specific international issues without an enforcement mechanism. The G-20, G-8, and BRICS processes each serve as contemporary examples of these informal institutions.[1] Theory concerning the conditions under which states choose each type of agreements and the consequences of these choices remain, as Vabulas and Snidal point out, under-determined.

Second, compliance with international regimes varies from agreement to agreement and state to state. For example, the vast majority of states party to the NPT have eschewed the development of nuclear weapons—and some the development of nuclear technology for

[1] Vabulas and Snidal, "Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements."

peaceful purposes altogether. However, other states that have signed up to the Treaty—most notably Iran and North Korea—have failed to abide by its restrictions on uranium enrichment.[2] Outside of security regimes, compliance with climate change accords and international economic institutions including the World Trade Organization have also varied considerably, with little by of theorizing how the the institutional design of the agreements affect state behavior.

This variation—as well as the interaction between agreement design and state behavior—remains under-examined in the institutional design literature despite the potential for the academy's understanding of design characteristics to shape downstream consequences. This dissertation seeks to address this gap in the theoretical literature by providing an empirical analysis of institutional design in the context of arms control and tracking compliance outcomes on an agreement-year basis, as shown in Figure 2.1.

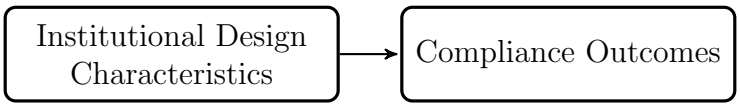

Figure 2.1: This figure outlines the argument of the dissertation as a whole.

In the chapter to follow, I examine the existing literature concerning the institutional design of international institutions. Then, I examine existing treatments of compliance. Finally, I outline how theoretical approaches to institutional design and compliance will be applied to the research design outlined in Chapter 3.

While this chapter reviews a considerable portion of the academic literature pertaining to international institutions from realist, liberal, constructivist, and rationalist perspectives, it is by no means exhaustive as scholars have long sought to understand the conditions under which cooperation among states "breaks out."[3] As such, this work does not represent a treatise on international cooperation.[4] Instead, it focuses on a particular cooperation

[2]Other states—including India, Pakistan, and Israel—have avoided joining the regime altogether.

[3]Charles Lipson, "International cooperation in economic and security affairs," *World Politics* 37, no. 1 (1984): 1–23; Joseph M Grieco, "Realist theory and the problem of international cooperation: Analysis with an amended prisoner's dilemma model," *The Journal of Politics* 50, no. 3 (1988): 600–624; Robert Jervis, "From balance to concert: a study of international security cooperation," *World Politics* 38, no. 1 (1985): 58–79; Ken Booth and Nicholas Wheeler, *The security dilemma: Fear, cooperation, and trust in world politics* (Springer Nature, 2007); Katja Weber, "Hierarchy amidst anarchy: A transaction costs approach to international security cooperation," *International Studies Quarterly* 41, no. 2 (1997): 321–340.

[4]Duncan Snidal, "Relative gains and the pattern of international cooperation," *American Political Science Review* 85, no. 3 (1991): 701–726; Peter M Haas et al., *Knowledge, power, and international policy coordination* (University of South Carolina Press Columbia, SC, 1992); Scott Barrett, "A theory of full international cooperation," *Journal of Theoretical Politics* 11, no. 4 (1999): 519–541; James D Fearon, "Bargaining, enforcement, and international cooperation," *International Organization* 52, no. 2 (1998): 269–305; Stephan Haggard and Beth A Simmons, "Theories of international regimes," *International Organization* 41, no. 3 (1987): 491–517. Milner, in particular, provides a useful review of this literature in her 1992 article: Helen Milner, "International theories of cooperation among nations: Strengths and weaknesses," *World Politics* 44, no. 3 (1992): 466–496.

challenge—arms control—as a prism through which to (re)assess existing international theory.[5]

2.2 Institutional Design in Theory

The academic debate surrounding the effects of international institutions has been driven, in large part, by whether and how institutions shape state behavior.[6] Indeed, cooperation under conditions of anarchy—particularly related to government decisions concerning their security—has long been a focus of international relations scholarship.[7]

However, much of the existing literature concerning the design of international institutions and their effects upon international cooperation have leveraged comparatively rich empirical examples of international cooperation concerning economic cooperation—engaging with debates concerning compliance with GATT/WTO rulings and state participation in supranational institutions—and environmental agreements.[8] The same is true of existing work related to escape clauses that allow states to leave an agreement—and of which sunset clauses represent a subset.[9] While this is understandable given the relatively high number of these types of agreements, it perhaps ignores the class of agreements that are most diffi-

[5]The dissertation also seeks to re-examine the conventional wisdom among policy-makers concerning the appropriateness and hypothesized effects of various types of arms control agreement designs.

[6]John J Mearsheimer, "The false promise of international institutions," *International Security* 19, no. 3 (1994): 5–49; Robert O Keohane and Lisa L Martin, "The promise of institutionalist theory," *International Security* 20, no. 1 (1995): 39–51.

[7]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Beth A. Simmons, "Treaty compliance and violation," *Annual Review of Political Science* 13 (2010): 273–296; Beth A Simmons, "International law and state behavior: Commitment and compliance in international monetary affairs," *American Political Science Review* 94, no. 4 (2000): 819–835; Michael Tomz, *Democratic default: Domestic audiences and compliance with international agreements* (Stanford University Press, 2002); Kenneth W Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements," *Cornell International Law Journal* 26 (1993): 1; Mitchell, "Regime design matters: intentional oil pollution and treaty compliance"; Harald Muller, "Compliance politics: A critical analysis of multilateral arms control treaty enforcement," *The Nonproliferation Review* 7, no. 2 (2000): 77–90; Chayes and Chayes, "Compliance without enforcement: state behavior under regulatory treaties"; Chayes, "An inquiry into the workings of arms control agreements"; Haggard and Simmons, "Theories of international regimes."

[8]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, "Loosening the ties that bind: A learning model of agreement flexibility"; Barbara Koremenos, Charles Lipson, and Duncan Snidal, "The rational design of international institutions," *International organization* 55, no. 4 (2001): 761–799; Mattli and Woods, *The politics of global regulation*; Oran R Young, *Compliance & public authority: A theory with international applications* (RFF Press, 2013); Ronald B Mitchell, "Problem structure, institutional design, and the relative effectiveness of international environmental agreements," *Global Environmental Politics* 6, no. 3 (2006): 72–89.

[9]Krzysztof J Pelc, "Seeking escape: The use of escape clauses in international trade agreements," *International Studies Quarterly* 53, no. 2 (2009): 349–368; B Peter Rosendorff and Helen V Milner, "The optimal design of international trade institutions: Uncertainty and escape," *International Organization* 55, no. 4 (2001): 829–857.

cult to reach—that is, cooperative frameworks pertaining to security concerns. Additionally, existing work on security institutions primarily focuses on ceasefire agreements and peace agreements in the context of inter- and intra-state conflict rather than on arms control..[10]

Building upon existing theory and empirical advancements and following the example of Kreps—who first quantitatively explored the institutional design of arms control in the context of the role of legalization affecting the entry into force of agreements—this project asks the question of whether theory developed to describe and explain patterns of cooperation in the realm of "low politics" have effects in the domain of "high politics."[11]

Indeed, scholarly inquiry into the causes and consequences of arms control agreements have been altogether more rare and have tended to focus on individual case studies of specific agreements, historical accounts, and future-oriented policy prescriptions rather than empirical inquiry.[12] In the sections to follow, I examine the existing literature drawing from several theoretical traditions within international relations—beginning with realist approaches—that address the question of how institutional design characteristics might shape patterns of state behavior.

2.3 Institutional Institutions and Realpolitik

Perhaps the most well-known approach to institutions—including arms control—from the realist canon comes from the work of Mearsheimer in which he writes that "institutions have

[10]Barbara F Walter, "Designing transitions from civil war: Demobilization, democratization, and commitments to peace," *International Security* 24, no. 1 (1999): 127–155; Virginia Page Fortna, "Scraps of paper? Agreements and the durability of peace," *International Organization* 57, no. 2 (2003): 337–372; Brett Ashley Leeds and Burcu Savun, "Terminating alliances: Why do states abrogate agreements?," *The Journal of Politics* 69, no. 4 (2007): 1118–1132; Suzanne Werner and Amy Yuen, "Making and keeping peace," *International Organization* 59, no. 2 (2005): 261–292; Michaela Mattes and Burcu Savun, "Fostering peace after civil war: Commitment problems and agreement design," *International Studies Quarterly* 53, no. 3 (2009): 737–759; Aila M Matanock, *Electing Peace: From Civil Conflict to Political Participation* (Cambridge University Press, 2017); Virginia Page Fortna, *Peace time: Cease-fire agreements and the durability of peace* (Princeton University Press, 2018).

[11]Kreps, "The institutional design of arms control agreements."

[12]Chayes, "An inquiry into the workings of arms control agreements"; Richard Dean Burns, "Arms Control and Disarmament," *A Bibliography. Santa Barbara*, 1977, Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements"; Emanuel Adler, "The emergence of cooperation: national epistemic communities and the international evolution of the idea of nuclear arms control," *International Organization* 46, no. 1 (1992): 101–145; Croft, *Strategies of arms control: a history and typology*; Ivo H Daalder, "The future of arms control," *Survival* 34, no. 1 (1992): 51–73; Fuhrmann and Lupu, "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty"; Nancy W Gallagher, "Bridging the gaps on arms control," *Contemporary Security Policy* 18, no. 2 (1997): 1–24; Keith Krause and Andrew Latham, "Constructing non-proliferation and arms control: The norms of Western practice," *Contemporary Security Policy* 19, no. 1 (1998): 23–54; Robin Ranger, *Arms and Politics, 1958-1978: Arms Control in a Changing Political Context* (Macmillan of Canada, 1979); Joseph S Nye, "Arms control after the cold war," *Foreign Affairs* 68, no. 5 (1989): 42–64; Marc Trachtenberg, "The Past and Future of Arms Control," *Daedalus*, 1991, 203–216; Thomas C Schelling, "What went wrong with arms control?," *Foreign Affairs* 64, no. 2 (1985): 219–233.

minimal influence on state behavior and thus hold little prospect for promoting stability in a post-Cold War world."[13] Scholars of the realist tradition remain skeptical concerning the utility of treaties and international law without an associated coercive apparatus that reflect inter-state power dynamics—that is, a powerful state to exercise coercion. Privileging relative gains concerns and characterizing the relations between states as a Prisoner's Dilemma in which trust is difficult to achieve, realist scholars have tended to be skeptical concerning the role of arms control, specifically, and international institutions, in general..[14] Valentino, Huth, and Croco, for example, contend that "whatever pressures toward restraint these treaties may exert on their signatories appear to be overwhelmed by the strategic incentives that combatants face to prevail and limit the costs of war to their own citizens.[15] Similarly, Bohlen argues that "treaties are powerless to deter determined cheaters, in part because they lack enforceable sanctions for violations. For that reason, the response to violations will necessarily lie in political or military action by the international community or individual states outside the treaty or regime."[16] Following this line of argument, a number of analysts and policy-makers continue to argue that arms control has been and will always be a dangerous illusion.[17]

Others within the realist tradition treat arms control as a useful but ultimately peripheral process that can reduce the costs and risks of competitive security policies at the margins.[18] Within this process, international institutions represent a cipher or manifestation of state power. Gavin, for example, suggests that "identifying the nuclear arms race as the driving force behind the Cold War—instead of the geopolitical and ideological conflicts between the Soviet Union and the United States—has led many analysts to overstate the importance of arms control treaties and regimes, both in the past and today."[19] Harking back to disarmament as a condition of victory, Betts argues that there remains a "gap between the instinctive appeal of the idea [arms control] in liberal cultures as they settle epochal conflicts, and its inherent defects in relations among independent states as they move from peace toward war."[20]

In discussions concerning how states design institutions and how they work, realist scholarship also tends to privilege relative power between state parties with the suggestion that institutional design choices favor the more powerful over the less powerful. In a study

[13]Mearsheimer, "The false promise of international institutions."

[14]Robert Jervis, "Cooperation under the security dilemma," *World Politics* 30, no. 2 (1978): 167–214; Kenneth N Waltz, *Theory of International Politics* (Waveland Press, 1979); Van Evera, "The cult of the offensive and the origins of the First World War"; Mearsheimer, "The false promise of international institutions."

[15]Benjamin Valentino, Paul Huth, and Sarah Croco, "Covenants Without the Sword International Law and the Protection of Civilians in Times of War," *World Politics* 58, no. 3 (2006): 339–377.

[16]Bohlen, "The rise and fall of arms control."

[17]Colin S Gray, "Arms control does not control arms," *Orbis* 37, no. 3 (1993): 333–348.

[18]Jervis, "Cooperation under the security dilemma."

[19]Gavin, "Same As It Ever Was: Nuclear Alarmism, Proliferation, and the Cold War."

[20]Richard K Betts, "Systems for peace or causes of war? Collective security, arms control, and the new Europe," *International Security* 17, no. 1 (1992): 5–43.

of CoCom—a military technology export control framework—and economic containment, Mastanduno suggests that hegemonic leadership plays an integral role in maintaining cooperation among states within an institution.[21] Further, as Benvenisti and Downs observe, "a fragmented legal order provides powerful states with much needed flexibility... the existence of multiple contesting institutions removes the need for them to commit themselves irrevocably to any given one.[22] This helps them to manage risk, and it increases their already substantial bargaining power. Kreps and Arend—in what they describe as a positional theory of adherence—also include aspects of state power in their explanation of why states comply with international regimes: "the most significant determinants of behavior are the position of that state in the international system."[23] Moreover, "the nature of the treaty regime, the extent to which the regime infringes on state sovereignty, the nature of verification [and] enforcement arrangements of that regime, and the normativity of the treaty regime" represent subsequent considerations that affect patterns of cooperation and state behavior.[24]

Broadly, realist scholarship suggests that arms control regimes constrain states only when they allow themselves to be constrained or they are coerced into compliance. However, this explanation fails to account for either the variation in institutional design frameworks used to govern military technologies or the variation in state behavior within and among agreements. Moreover, the existence of arms control frameworks that constrain the most powerful states without constraining their less powerful adversaries offers something of a puzzle for this theory. These scholars, perhaps unsurprisingly, rarely take the institutional design of arms control agreements into account in their scholarship.

2.4 Normative Theory

Unlike scholars that view arms control as symptomatic of broader power relations, normative scholars suggest that arms control agreements represent an outcome of a shift in the "logic of appropriateness" concerning the developments and deployment of military technology among states. Some scholars suggest that this process represents a "social process" among and between states and subsidiary interest groups.[25] In simple terms, they argue that specific types of weapons systems have become normatively undesirable and that this has led to a

[21]Michael Mastanduno, *Economic containment: CoCom and the politics of East-West trade* (Cornell University Press, 1992).

[22]Eyal Benvenisti and George W Downs, "The empire's new clothes: political economy and the fragmentation of international law," *Stan. L. Rev.* 60 (2007): 595.

[23]Kreps and Arend, "Why States Follow the Rules: Toward a Positional Theory of Adherence to International Legal Regimes."

[24]Ibid.

[25]Nina Tannenwald, "The nuclear taboo: The United States and the normative basis of nuclear non-use," *International Organization* 53, no. 3 (1999): 433–468; Margaret E Keck and Kathryn Sikkink, *Activists beyond borders: Advocacy networks in international politics* (Cornell University Press, 2014); Richard Price, "A genealogy of the chemical weapons taboo," *International Organization* 49, no. 1 (1995): 73–103.

"taboo" against their use. Below, I point to scholarship on norms concerning nuclear use, chemical weapons, and landmines to illustrate the normative approach to arms control.

With regard to weapons bans, in particular, constructivist scholars describe the eradication of specific classes of weapon technology in normative rather than strategic terms. Price, for example, tracks the genealogy of efforts to ban and eradicate chemical weapons in a study of mustard gas and nerve agents. Tannenwald, too, describes efforts to ban nuclear weapons and the development of opposition to nuclear weapons in normative terms. This opposition, she argues, is central to the non-use of nuclear weapons since the attacks on Hiroshima and Nagasaki, respectively. In both cases, the concept of a "taboo" has been used to describe state compliance with a variety of norms.[26] Work on landmines and small arms have followed in this vein suggesting that norms against military technology become "institutionalized" in arms control regimes.[27]

More theoretical work from constructivist scholars use "structurationist" approaches to examine the domestic, national, and international drivers of international cooperation surrounding arms control given "constructed" or "socialized" ideas of technology effects and their consequences for international stability. Adler, for example, points to the role of thought leaders—Brodie, Ellsberg, Hoag, Kahn, Kaufmann, Schelling, Halperin and Wohlstetter—in disseminating ideas concerning the appropriate responses to the challenge posed by nuclear weapons to states.[28] Krause and Latham's more recent scholarship also suggest that norms and ideas internalized by states drive nonproliferation, arms control, and disarmament policies lead to their receptiveness to traditional arms control frameworks.[29]

Normative scholars, then, tend to consider the conditions under which arms control agreements are produced—rather than their design or consequences. Keck and Sikkink, however, pose the central question for both scholars and policy-makers concerning arms control: "[the] socialization literature theorizes the diffusion of norms over time and space, but it is still puzzling as to why some norms seem to be internalized and complied with more than others."[30] This puzzle serves as a motivating question for this project as it seeks to explain both the observed variation in the institutional form of arms control agreements and the subsequent effect of these varied characteristics on compliance.

[26]Tannenwald, "The nuclear taboo: The United States and the normative basis of nuclear non-use"; Nina Tannenwald, "Stigmatizing the bomb: Origins of the nuclear taboo," *International Security* 29, no. 4 (2005): 5–49; Price, "A genealogy of the chemical weapons taboo."

[27]Denise Garcia, *Small arms and security: new emerging international norms* (Routledge, 2006).

[28]Adler, "The emergence of cooperation: national epistemic communities and the international evolution of the idea of nuclear arms control."

[29]Krause and Latham, "Constructing non-proliferation and arms control: The norms of Western practice"; Keith R Krause, *Culture and security: multilateralism, arms control and security building* (Routledge, 2012).

[30]Keck and Sikkink, *Activists beyond borders: Advocacy networks in international politics.*

2.5 Domestic Politics

Yet other scholars suggest that domestic politics plays a central role in conditioning state behavior and international cooperation.[31] The most obvious linkage between domestic politics and arms control stem from scholarship examining models of bureaucratic politics. In research suggesting that domestic political imperatives decrease the likelihood of arms control, Miller points out that arms control represents an effort to interfere with the defense policy process, to constrain certain kinds of weapons, options, and practices for the "greater good" of national security.[32] He goes on to note that this process engages the interests of defense decision-making and weapons acquisition bureaucracies. These actors, he notes, seek security not by constraining or eliminating weapons and military options but by providing them.[33] Thus, state compliance reflects the proclivities of domestic interest groups.

Functionalists, in particular, often argue that governments cooperate with each other because of increasing material demands from domestic actors.[34] As Moravcsik argues, "states... represent some subset of domestic society, on the basis of whose interests state officials define state preferences and act purposively in world politics."[35] Martin, Milner, Tomz, Leeds and others have also suggested that domestic signaling by state leaders to the electorate in democratic states impacts international cooperation and compliance with international agreements.[36] This analysis has come to focus on audience costs and the "hand-tying" nature of international commitments on state leaders as drivers of domestic behavior. Jessica Weeks has also made the argument that these audience costs impact autocratic leaders as well as democratic leaders—though the respective causal mechanism varies on the basis of regime type.[37] With regard to public attitudes concerning arms control, there are few studies and little theorizing concerning how domestic preferences percolate to policy-making. Indeed, Platt in an 1982 RAND study found that public attitudes toward arms control have been schizophrenic at best—despite the role of Congress in the ratification process of the

[31] Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

[32] Steven E Miller, "Politics over promise: Domestic impediments to arms control," *International Security* 8, no. 4 (1984): 67–90.

[33] Ibid.

[34] Cheryl Shanks, Harold K Jacobson, and Jeffrey H Kaplan, "Inertia and change in the constellation of international governmental organizations, 1981–1992," *International organization* 50, no. 4 (1996): 593–627.

[35] Andrew Moravcsik, "Taking preferences seriously: A liberal theory of international politics," *International Organization* 51, no. 4 (1997): 513–553.

[36] Lisa L Martin, *Democratic commitments: Legislatures and international cooperation* (Princeton University Press Princeton, 2000); Tomz, *Democratic default: Domestic audiences and compliance with international agreements*; Brett Ashley Leeds, "Domestic political institutions, credible commitments, and international cooperation," *American Journal of Political Science*, 1999, 979–1002; Edward D Mansfield, Helen V Milner, and B Peter Rosendorff, "Why democracies cooperate more: Electoral control and international trade agreements," *International Organization* 56, no. 3 (2002): 477–513.

[37] Jessica L Weeks, "Autocratic audience costs: Regime type and signaling resolve," *International Organization* 62, no. 1 (2008): 35–64.

United States.[38] In follow-up work using country-agreement-year and dyad-agreement-year data rather than agreement-year data, I explore the domestic determinants of institutional design and compliance with arms control agreements.[39]

2.6 Utilitarian Theory

Finally, I turn to utilitarian approaches to institutional design and arms control. In simplest terms, this theory suggests that "form follows function" and that institutional design represents deliberate attempts to solve bargaining and enforcement challenges—reflecting state interests during the period in which international institutions are negotiated as well as an attempt to subsequently shape state behavior.

Scholars from this tradition argue that arms control agreements, like other forms of cooperation, offer tangible benefits to participants and that when they do, we should expect them to be created—even among adversaries.[40] Schelling alludes to the inherent cooperative structure of these arrangements as "games in which, though the element of conflict provides the dramatic interest, mutual dependence is part of the logical structure and demands some kind of collaboration or mutual accommodation."[41] What are these benefits? According to Schelling and Halperin, arms control frameworks have three goals: to reduce the probability of war by reducing uncertainty and crisis instability, to reduce the cost of war, and to reduce the cost of preparing for war.[42] In discussions with former arms control negotiators, many note that negotiations have primarily focused on the ability of arms control to contribute to crisis stability by allowing for greater predictability during crises.[43] Yet others posit a more tautological pursuit of arms control not for its benefits but as an end in itself: "the 'arms race' is commonly believed to be a major cause of international tension; it follows that the "control of the arms race" is to be sought as a kind of end in itself."[44] Scholars

[38] Alan Platt, *The Politics of Arms Control and the Strategic Balance*, technical report (RAND Corporation, Santa Monica CA, 1982).

[39] As a result of choices taken to parse the arms control regime data, theory pertaining to domestic politics are left out of the subsequent quantitative chapters.

[40] Hedley Bull, "The Control of the Arms Race: Disarmament and Arms Control in the Missile Age.(Studies in International Security, II.)," *The Annals of the American Academy of Political and Social Science*, 1962, Keohane and Martin, "The promise of institutionalist theory"; Susanne Therese Hansen, "Taking ambiguity seriously: Explaining the indeterminacy of the European Union conventional arms export control regime," *European Journal of International Relations* 22, no. 1 (2016): 192–216; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions"; Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

[41] Thomas C Schelling, "The strategy of conflict. Prospectus for a reorientation of game theory," *Journal of Conflict Resolution* 2, no. 3 (1958): 203–264.

[42] Schelling and Halperin, "Strategy and Arms Control."

[43] Interview with Amb. Linton Brooks, March 19, 2018. This account is consistent with other inteviews carried out in Washington, DC under the Chatham House Rule.

[44] Trachtenberg, "The Past and Future of Arms Control."

of institutional design—of both functionalist and rational persuasions—have considered how the design characteristics of international agreements reflect these utilitarian considerations. Others have also suggested that existing institutions adapt to new circumstances with shifting priorities and institutional structures that reflect these utilitarian considerations.[45]

Following the functionalist literature that points to the variety of roles that international institutions play in international relations, institutionalist theory began to consider the role and purpose of international organizations in the form of regime. Institutionalist scholars have defined regimes as "implicit or explicit principles, norms, rules and decision-making procedures around which actors' expectations converge in a given area of international relations."[46] Further, scholars suggested that the variation in international institutions was driven "by purposes they serve, the instrumentalities they use, and the functions these instrumentalities actually perform."[47] These institutions provide a "set of mutual expectations, rules and regulations, plans, organizational energies and financial commitments allowing for cooperation to occur.[48] But, why would sovereign states create these institutions that impinge upon their ability to act?

In simple terms, institutions offer states a pathway toward a desired end. Some scholars suggest that states pursue their interests strategically and use multilateral institutions when unilateral actions are unavailable or unlikely to have the desired effect. They further argue, "treaties are signed on the basis of material cost-benefit calculations."[49] Koremenos, Lipson, and Snidal go further to suggest that regime design and attempts to change regimes represent the sum of rational, utilitarian, and purposive interactions among states.[50] They go on to argue that "states use international institutions to further their own goals, and they design institutions accordingly."[51] In a similar vein, Keohane and Martin suggest that, "when states can jointly benefit from cooperation we expect governments to attempt to construct such institutions."[52] What are these benefits? "Institutions can provide information, reduce transaction costs, make commitments more credible, establish focal points for coordination, and in general facilitate the operation of reciprocity."[53] These benefits are also arguably easier to achieve in an environment with repeated games.[54] Recent work, reflecting research on "institutional nesting," has also pointed to the importance of the "institutional context"

[45]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting.*

[46]Stephen D Krasner, *International regimes* (Cornell University Press, 1983).

[47]John Gerard Ruggie, "International responses to technology: concepts and trends," *International organization* 29, no. 3 (1975): 557–583.

[48]Ibid.

[49]Hansen, "Taking ambiguity seriously: Explaining the indeterminacy of the European Union conventional arms export control regime"; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[50]Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[51]Ibid.

[52]Keohane and Martin, "The promise of institutionalist theory."

[53]Ibid.

[54]Celeste A. Wallander, "Institutional assets and adaptability: NATO after the Cold War," *International Organization* 54, no. 4 (2000): 705–735; Robert Axelrod and Robert O Keohane, "Achieving cooperation under anarchy: Strategies and institutions," *World Politics* 38, no. 1 (1985): 226–254.

in which new agreements are embeddedas well as the existing and prior agreements among prospective partners in "new" agreement.[55]

Unlike theories that privilege the domestic drivers of arms control frameworks, this theory suggests that utility is derived from the benefits of achieving arms control and that institutional design follows—that is, form follows function. Bohlens account of arms control during the Cold War underscores this theory: "in a period marked by uncertainty, tension and enormous potential for instability—especially within the former Soviet Union—the treaties created a structured and predictable environment."[56] As hand-wringing over the future of arms control in the 21st century continues, this structured and predictable environment is what many scholars and policy-makers view as being at stake.

The information and commitment problems that James Fearon outlines in the "Rationalist Explanations of War are illustrative of the challenges facing states as they attempt to create arms control institutions.[57] In the realm of arms control, Gallagher suggests, "misperceptions, not objective conflicts of interest, are the primary cause of arms races, security dilemmas, and deterrence instabilities."[58] As a consequence one of the goals of arms control frameworks are to provide information about state intentions.[59] This reality underlines the importance of verification mechanisms included in a variety of arms control frameworks.

In the dissertation to follow, I examine several hypotheses informed by the theoretical approaches discussed above using the both quantitative and qualitative methods using an original Arms Control Design Dataset (ACDD) described in greater detail in the chapter to follow. There are a variety of impacts of institutional design worthy of scholarly attention. In the proceeding chapters, I consider methods to address the effects of arms control agreements with varying design characteristics (specifically the types of agreement, verification regimes, flexibility mechanisms, and membership in an regime).

As Young notes in his work on environmental regimes, "the ultimate justification for devoting substantial time and energy to the study of regimes must be the proposition that we can account for a good deal of the variance in collective outcomes at the international level in terms of the impact of institutional arrangements."[60]

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[55]Mark S Copelovitch and Tonya L Putnam, "Design in context: existing international agreements and new cooperation," *International Organization* 68, no. 2 (2014): 471–493; Miles Kahler, "Evolution, choice, and international change," *Strategic Choice and International Relations*, 1999, 165–96; Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting.*

[56]Bohlen, "The rise and fall of arms control."

[57]James D Fearon, "Rationalist explanations for war," *International Organization* 49, no. 3 (1995): 379–414.

[58]Gallagher, "Bridging the gaps on arms control."

[59]Vince Manzo, *Nuclear Arms Control Without a Treaty? Risks and Options After New START*, technical report (Center for Naval Analyses, 2019).

[60]Oran R Young, *International cooperation: Building regimes for natural resources and the environment* (Cornell University Press, 1989).

2.7 From Theory to Analysis

To address this challenge, the dissertation proceeds by describing the quantitative methods that leverage the empirical record associated with arms control to investigate how varying the characteristics of arms control affects compliance. In the process, I introduce the Arms Control Design Dataset (ACDD)—the first database used to track the design characteristics of arms control regimes on the basis of their respective Treaty texts.

This dataset allows for an empirical analysis of the institutional design theories discussed above in the context of security arrangements—adding an important set of observations to the scholarly record as well as contributing to a re-examination of the accepted wisdom surrounding the effects of institutional design. Not only does the analysis test *whether* institutions matter, it tests *how* they matter.

Chapter 3

Research Design: Examining Compliance and the Variation in Arms Control Design

Abstract

In this chapter, I outline the quantitative methods employed in the quantitative chapters of the dissertation. Specifically, I outline the coding criteria of variables included in the Arms Control Design Dataset (ACDD) before outlining the modeling approaches used to derive the predicted probability of compliance on an agreement-year basis given the presence or absence of specific institutional design parameters. The chapter also includes an account of all episodes of non-compliance coded as the dependent variable in the analysis to follow.

3.1 Introduction

Much of the existing work concerning arms control considers the conditions under which arms control occurs.[1] Recent scholarship, for example, considers how leadership traits affect adversarial cooperation and arms control treaty ratification.[2] Research concerning the consequences of arms control is altogether more rare. Fuhrmann and Lupu's (2016) treatment of the Nuclear Non-Proliferation Treaty (NPT) in an article provocatively titled, "Do Arms Control Treaties Work?" offers a primary example of scholarship aimed to assess the effects

[1]Betts, "Systems for peace or causes of war? Collective security, arms control, and the new Europe"; Andrew Kydd, "Arms races and arms control: Modeling the hawk perspective," *American Journal of Political Science*, 2000, 228–244.

[2]Kreps, Saunders, and Schultz, "The Ratification Premium: Hawks, Doves, and Arms Control"; Michaela Mattes and Jessica LP Weeks, "Hawks, Doves, and Peace: An Experimental Approach," *American Journal of Political Science* 63, no. 1 (2019): 53–66; Kreps, Saunders, and Schultz, "The Ratification Premium: Hawks, Doves, and Arms Control."

of arms control—even if it focuses upon just one of the myriad agreements designed to limit the development of nuclear arms. Indeed, it is rare that only one institutional design could perform these functions in a satisfactory way. As a result arms control negotiators have scope for choice.[3]

In this chapter, I outline a research design to quantitatively examine the consequences of this choice and that expands the number of cases considered in the existing literature and subjects them to a systematic investigation. In the process, I introduce the Arms Control Design Dataset (ACDD) used for the empirical analysis in Chapters 4-7. First, I outline the dependent variable of interest: compliance with an arms control agreement. Then, I describe each of the independent variables that are subject to analysis in the following chapters while also describing their prior treatment in the existing literature. Third, I describe the control variables analyzed throughout this study. I then outline the modeling approaches used within the study to follow within the quantitative chapters of the dissertation. Throughout, I include a number of empirical examples to illustrate how each of the variables have been coded—including an in-depth explanation of the coding criteria related to compliance and non-compliance.

3.2 Introducing the Arms Control Design Dataset (ACDD) v.1

In the section to follow, I introduce the original Arms Control Design Dataset (ACDD). The dataset is designed to systematically track the design parameters of intergovernmental arms control agreements from 1945 through June 2019. At this stage, the dataset focuses on examples of nuclear arms control.[4]

3.2.1 Selection Criteria

In the initial build of the ACDD, I use Kreps's list of forty-six nuclear-related arms control agreements as the selection criteria for inclusion in the dataset.[5] Of those, thirty-six meet the condition of having entered into force and not representing an international institution rather than an international agreement.[6] I use this selection criteria to avoid researcher-introduced bias into the dataset though there are a number of additional nuclear and non-nuclear agreements coded and available for analysis.[7]

[3]Alexander Ovodenko and Robert O Keohane, "Institutional diffusion in international environmental affairs," *International Affairs* 88, no. 3 (2012): 523–541.

[4]I discuss the logic of this decision below.

[5]Kreps, "The institutional design of arms control agreements."

[6]As noted in each of the quantitative chapters, it is perhaps unreasonable to expect states to comply with agreements that have not entered into force. Kreps also considers the IAEA as a separate arms control

Agreement	Year EIF
COCOM	1950
Antarctic Treaty	1959
Limited Test Ban Treaty	1963
Hotline Treaty	1963
Space Treaty	1967
Treaty of Tlatelolco	1969
Nuclear Non-Proliferation Treaty	1970
Accidents Measures Agreement	1971
ABM Treaty	1972
Seabed Treaty	1972
Interim Agreement, SALT I	1972
Zangger Committee	1974
Prevention of Nuclear War Agreement	1974
Nuclear Suppliers Group	1978
Moon Agreement	1984
Treaty of Rarotonga	1986
Convention on the Physical Protection of Nuclear Material	1987
Missile Technology Control Regime	1987
Intermediate Range Nuclear Material	1988
Threshold Test Ban Treaty	1990
Peaceful Nuclear Explosion Treaty	1990
India-Pakistan Non-Attack Agreement	1991
Lisbon Protocol	1991
Conventional Forces in Europe (CFE) Treaty	1992
START I	1994
Trilateral Statement	1994
Wassenaar Agreement	1996
Treaty of Bangkok (Southeast Asia NWFZ)	1997
Trilateral Comprehensive Test Ban Negotiations	1997
Lahore Declaration	1999
Mongolia Nuclear Weapon Free Zone	2000
Strategic Offensive Reductions Treaty (SORT)	2002
Proliferation Security Initiative	2003
UNSC Resolution 1540	2004
Nuclear Terrorism Convention	2007
African NWFZ	2009
Central Asia Nuclear Weapon Free Zone (Treaty of Semei)	2009
New START	2010

Table 3.1: This table notes those agreements included in ACDD v.1 as well as the year that they entered into force.

3.2.2 Unit of Analysis: Agreement-Year

The ACDD is comprised of arms control design data on an agreement-year basis in which I code institutional design characteristics on an annual basis. As such, it includes columns for both *Year* and *Agreement* along with a column for *Description*. This agreement-year treatment mirrors the past quantitative treatments of the institutional design of arms control.[8] As an example, the Missile Technology Control Regime established in April 1987 is included in the dataset from 1987 until the present. Each of its institutional design characteristics, from membership to scope is coded for each of the agreement years. When agreements end either via a termination clause, like START I in 2009, or via abandonment, as was the case with the ABM Treaty in 2002, they drop out of the dataset. The dataset is also sensitive to changes in a regime over time (on an annual basis). For example, START I was multilateralized following the end of the Cold War as former Soviet states were included in the regime. In follow-up work, I envision using the agreement-year data to build a country-agreement-year database.[9]

At the time of writing, the ACDD includes 1,187 agreement-years for analysis.

3.3 Analyzing Compliance: The Dependent Variable

As noted in Chapter 1, the dependent variable of interest is compliance on an agreement-year basis. The ACDD treats this as a dichotomous measure of whether an agreement is complied with on an annual basis. There are several criteria associated with coding compliance and non-compliance using academic, historical, and journalistic sources.[10] Primarily, I am concerned with whether states parties perform actions that violate agreed treaty language. This dichotomous measure does not assess whether non-compliance with an agreement proffers a strategic advantage, non-compliance was accidental, or whether non-compliance enhances a state's military capacity vis á vis other states parties—each of which may be of interest for follow-up study.

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agreement.

[7]The minilateral Joint Comprehensive Plan of Action (JCPOA) involving Iran and the P5+1 serves as an example of an agreement left out of Kreps's list but is considered in the later chapters of this dissertation.

[8]Kreps, "The institutional design of arms control agreements."

[9]Using country-agreement-year as the unit of analysis would allow for country-based control variables such as regime type and GDP that may affect decisions to meet a state's international obligations. The challenge of such an approach is determining the appropriate scope of the countries to be included in the dataset—whether the P5 or the nine states alleged to have nuclear weapons if focused on strategic arms control agreements or an even broader set of states for an analysis of non-stategic arms control.

[10]Several volumes were helpful in drawing my attention to episodes of non-compliance with arms control agreements. These include: Richard Dean Burns, *The evolution of arms control: from antiquity to the nuclear age* (Praeger Security International, 2009); Goldblat, *Arms control: a survey and appraisal of multilateral agreements*; Jozef Goldblat, *Arms Control: The New Guide to Negotiations and Agreements* (Sage, 2002); James A Schear, "Arms Control Treaty Compliance: Buildup to a Breakdown?," *International Security* 10, no. 2 (1985): 141–182; Gloria Duffy, "Arms control treaty compliance," *Encyclopedia of arms control and disarmament* 1 (1993): 279.

The consistent coding criteria for a determination of compliance and non-compliance used in the analysis to follow is: An agreement-year is measured as in compliance if all states parties are fulfilling their obligations under the Treaty. If a state should fulfill their obligations under the Treaty, it is scored as non-compliant within that agreement-year in which the non-compliance occurs. It is possible for those agreements that have non-compliant states parties to re-enter compliance as compliance is determined on an per-year basis. The ABM Treaty serves as an example of an agreement in which states parties are non-compliant before re-entering compliance. In this version of the ACDD, only agreement-years in which an agreement has entered into force are included. If an agreement is abandoned, it is taken out of the dataset. The CFE Treaty, for example, is taken out of the dataset following Russia's withdrawal from all of the Treaty's obligations in 2015.

In the sections below, I describe several episodes of non-compliance included in the ACDD dataset. In the dataset itself, agreement-years are coded as 0 when states parties are in breach of an agreement during that year and are coded as 1 when the provisions set out in the Treaty are met. I begin by examining several breaches of testing obligations before turning to breaches of the ABM, INF, CFE, and NPT, respectively.

3.3.1 Non-Compliance with Testing Bans

Upon signing and ratifying the Limited Test Ban Treaty, the United States took the view that any radiation released from an underground nuclear test that crossed an international border was a violation of the agreement, whereas the Soviet view was that there had to be fallout, for example, that the radiation so released was reaching the earth's surface. This disagreement may have contributed to a series of incidents in which air samples containing radionuclides outside the borders of the USSR following underground Soviet test explosions, which routinely led to U.S. charges that the treaty had been violated.[11]. The Soviet test of 15 January, 1965 serves as an example of such a test leading to Secretary of State Dean Rusk to send a démarche (or aide-memoire) to Soviet Ambassador Anatoly Dobrynin four days later.[12]. In April 1966, an underground PIN STRIPE weapons test at the Nevada Test Site also produced radioactive gases. According to recent documents published by the National Security Archive at George Washington University, the State Department feared that U.S. monitoring of French nuclear tests in 1972 via its NICE program may violate the LTBT.[13] The September 1979 "South Atlantic flash" or Vela Incident represents the final episode of

[11]See Treaty Banning Nuclear Testing in the Atmosphere, Oceans, and Outer Space, 480 UNTS 43 (1963)

[12]Memorandum of Conversation, "Signals Received of an Explosion in the Soviet Union," 19 January 1965, Secret; State Department aide memoire, 15 February 1965, unclassified, National Security Archive at George Washington University.

[13]Phillip Odeen, NSC Staff, to Dr. Kissinger, "Observations of 1972 French Nuclear Tests," 13 March 1972, enclosing memorandum from Secretary of Defense Laird to Kissinger, "Weapons Effect Data Collection from 1972 French Nuclear Tests," 3 March 1972; Burr, William (2013) *National Security Archive Electronic Briefing Book* No. 433.

non-compliance associated with the LTBT in the dataset. In each of these instances, I code these as examples of non-compliance in each agreement-year.

There are also a number of allegations of non-compliance that are not included in the dataset. The Threshold Test Ban Treaty signed in 1974 and that limits the yield of underground nuclear tests to under 150 kilotons by 1976 was a source of sustained consternation given the difficulty in both designing nuclear tests that do not break a specific yield threshold and difficulties associated with monitoring the yield of nuclear tests. A U.S. 1985 report titled, "Soviet Noncompliance With Arms Control Agreements," suggests that during the early 1980s "Soviet nuclear testing activities for a number of tests constitute a likely violation of legal obligations under the Threshold Test Ban Treaty of 1974 but these allegations were not included in subsequent compliance reports."[14] More recently, the United States via the Defense Intelligence Agency and White House has alleged that Russia has violated the Comprehensive Test Ban Treaty. The CTBTO has, at the time of writing, not corroborated this claim using its international monitoring system.[15] Given that the CTBT has yet to enter force and the lack of documentation surrounding both allegations, I do not include these episodes in the dataset.

3.3.2 The ABM Treaty

The ABM Treaty, signed in 1972, was designed to limit the number of anti-ballistic missile (ABM) complexes used to defend areas against nuclear missiles on a ballistic trajectory in both the United States and USSR. The construction of the Yeniseysk-15 phased array radar at Krasnoyarsk in central Siberia in 1980 led to allegations by the United States in 1983 that the USSR was in violation of its commitments to the ABM Treaty 1983 until 1987 when construction was halted.[16] Russia initially claimed that the site was designed for space surveillance rather than an ABM mission before later noting that the site was in breach of the ABM Treaty—the site was demolished in 1989. During this period, the United States also complained that the USSR's extensive antiaircraft system might be used in a way that might violate the ABM treaty. This latter concern was driven, in part, by ambiguity in the Treaty language concerning what constituted a "strategic" or "tactical" target.[17] Given these developments, the ACDD dataset codes the years following the allegation of breach in 1983 until the halting of the radar's construction in 1987 as non-compliance.[18]

[14] "Soviet Noncompliance With Arms Control Agreements" U.S. Department of State, Special Report No. 122, February 1985.

[15] Gordon, Michael (2019). "U.S. Says Russia Likely Conducting Low-Yield Nuke Tests, Defying Test Ban Treaty" *Wall Street Journal*. May 29, 2019.

[16] This violation was reported by the United States to the ABM Treaty's Standing Consultative Commission in autumn of 1983. See also: "United States: Unilateral Statement Following ABM Treaty Review" August 31, 1988; Archived by the Federation of American Scientists.

[17] This ambiguity remains at issue today.

[18] This is arguably a conservative approach given that construction began in 1980 and the facility was not demolished until 1989.

In the late 1990s, new developments concerning missile defense technologies contributed to efforts to amend the existing ABM Treaty by the Clinton administration. In an episode reminiscent of the Krasnoyarsk episode noted above, Russia alleged on 18 April, 2000 that the Globus-2 radar station under construction in the Norwegian town of Vardo represented a violation of the ABM Treaty—noting that that prior to being located in Norway, the radar was used in ABM tests in the United States. On December 13, 2001 President Bush officially announced that the United States was withdrawing from the ABM Treaty and exercising the provisions of Article XV of the Treaty, with the effective date of withdrawal six months following this announcement on June 13, 2002. At the time of the announcement, according to NTI, "the United States already had begun testing a ground-based system designed to intercept intercontinental ballistic missiles (ICBMs). The U.S. Navy had also been testing some components of a shipboard missile intercept system."[19] In August 2001, the Pentagon announced plans to deploy five ground-based interceptors in Fort Greely, Alaska. Given the developments in Norway, Alaska, and the decision to withdraw in 2001, I code agreement-years 2000-2002 as an episode of non-compliance in the dataset.

As U.S. Assistant Secretary of State for International Security and Non-Proliferation Chris Ford noted at the 2019 Carnegie International Nuclear Policy Conference referring to the ABM and in a discussion of INF systems, the United States made the decision to exercise the withdrawal provision in the Treaty rather than fail to abide by its commitments under the Treaty—though it offers one of the rare examples of Treaty abandonment.

3.3.3 Non-Compliance with the INF Treaty

The allegations of non-compliance associated with the Intermediate-Range Nuclear Forces (INF) Treaty from 2007 to 2019 are perhaps more clear-cut than those above.[20] The INF Treaty, designed to address "intermediate nuclear forces"—ground-launched ballistic missiles (GLBMs) and ground-launched cruise missiles (GLCMs) with ranges of between 1,000 and 5,500 kilometers—and their destabilizing consequences in the European theatre, sought to ban a specific type of nuclear delivery vehicle. A letter from President Obama to President Putin on May 28, 2014, the United States disclosed its determination that Russia was in breach of its INF obligations. According to the *New York Times*, "in May 2013, Rose Gottemoeller, the State Departments senior arms control official, first raised the possibility of a violation with Russian officials."[21] The violation centered on Russia's deployment of the 9M729 SSC-X-8 long-range ground-based cruise missile system that uses the Russian Iskander launcher. Expert accounts concerning the range vary but are generally believed to be between 300 miles and 3,400 miles—falling in the range addressed by the Treaty.

[19]Nuclear Threat Intitiative, "Treaty on the Limitation of Anti-Ballistic Missile Systems (ABM Treaty)." Available at: https://www.nti.org

[20]I discuss thee abrogation of the INF Treaty in greater depth in the following: Andrew W. Reddie, "Design Matters: The Past, Present and Future of the INF Treaty," *Trust & Verify* Issue No. 162.

[21]Gordon, Michael, "U.S. Says Russia Tested Cruise Missile, Violating Treaty" *New York Times*, July 28, 2014.

In discussions with former government officials in Washington, DC, they suggest that Russian plans to leave the INF Treaty predate the development and deployment of the 9M729 in 2007 and 2008. In the process, they note two factors that may have contributed to this decision. First, that the INF Treaty is no longer in Russia's strategic interest—particularly given the perceived asymmetrical effects across the signatories. In simplest terms, the INF Treaty impinges upon Russia's regional freedom of action in a manner not commensurate with the effects for the United States. Second, past negotiators noted that Moscow may have perceived the abrogation of the Treaty as being "costless" given the lack of attention paid to the Treaty following the sunset of its verification provisions, illustrated by the failure of the Special Verification Commission to meet between 2000 and 2016.[22]

To bring these developments up to date at the time of writing, the United States has initiated the withdrawal provision included in the Treaty with the agreement likely to be abandoned in August 2019.

For the purposes of the analysis carried out later in the dissertation, the ACDD codes the episode on non-compliance with the INF Treaty from 2007 through 2019.

3.3.4 Conventional Forces in Europe

Russia's non-compliance with the Conventional Forces in Europe (CFE) Treaty is more clear-cut still given that it announced its intention to suspend implementation of the treaty designed to limit conventional weapons deployments in Europe on December 12, 2007. Moscow also made clear that it would not provide a required year-end account of its forces required by the information exchange mechanism included in the Treaty. As a consequence of this announcement, Russia would no longer provide information to information exchanges or on-site inspections of its treaty-limited weapons including tanks, armored combat vehicles, heavy artillery, attack helicopters, and combat aircraft. The Foreign Ministry announcement also stated that Russia would not be "bound" by the Treatys arms ceilings and deployment restrictions. While Moscow announced its intention to no longer implement the Treaty, they remained a member of the Joint Consultative Group that governs the Treaty for almost eight years.

Following failed attempts to bring Russia back into compliance amid broader arms control discussions (not least New START negotiations in 2009), the United States announced that it would "would cease carrying out certain obligations" regarding Russia under the Treaty. On March 10, 2015, Moscow announced that it would no longer participate in meetings of the Joint Consultative Group, suspending the Treaty—at which point it drops out of the ACDD dataset. For the purposes of the ACDD dataset, this episode of non-compliance begins on 2007 and concludes in 2015.

[22] Article XIII of the INF Treaty notes that a meeting can be called "if either Party so requests"—but neither Party made this request until Russia's violation was made public.

3.3.5 Lahore Declaration

The failure of India and Pakistan to comply with the Lahore Declaration for two years following the Kargil crisis represents another example a non-compliance example included within the dataset. The Declaration designed to recognize the nuclear dimensions of conflict between the two countries and to create a series of confidence-building measures that reduce the risk of nuclear conflict (accidental or otherwise) was completed in February 1999. By May of the same year, the Kargil War had suspended these measures.[23] A softening of tensions between the two states in 2001 led both sides to re-engage in dialogue and the end of this particular episode of non-compliance tracked by the ACDD.

3.3.6 Nuclear Non-Proliferation Treaty

Episodes of non-compliance are also not limited to bilateral or minilateral contexts. The Nuclear Non-Proliferation Treaty (NPT) has also suffered a number of breaches associated with failures to safeguard nuclear material or abide by nonproliferation commitments. In the cases of Romania, South Korea, and Egypt, a single public noncompliance report from the International Atomic Energy Agency that serves as the NPT's monitoring organization led the governments of those three states to policy remedies. In five cases involving Libya, Syria, Iraq, North Korea, and Iran, compliance issues were altogether more complicated. The cases of North Korea and Iran are perhaps the most problematic from the perspective of compliance, with the former eventually withdrawing from the Treaty. Below, I describe episodes of non-compliance related to each.

North Korea's accession to the NPT begins controversially. While Pyongyang accedes to the Treaty in 1985, it fails to fulfill the obligations of membership spelled out in Article III that involves completing a safeguards agreement with the IAEA within 18 months of accession. Following the withdrawal of U.S. nuclear forces from the Korean peninsula in 1991, North Korea signs a safeguards agreement with the IAEA on January 30, 1992. By September of the same year, IAEA inspectors request clarifications of several issues provided by North Korea in their provisional report to the Agency. In February 1993, the IAEA demands access to two sites believed to hold nuclear waste. Pyongyang refuses this request and is no longer in compliance with the Treaty. At the same time, Pyongyang makes its first threat to withdraw from the Treaty by exercising Article X that reads, "Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests."[24] Pyongyang subsequently announced that it is suspending its withdrawal

[23]For an excellent analysis of the nuclear dimensions of the Kargil crisis, see: Ashley J. Tellis, C. Christine Fair, Jamison Jo Medby, "Limited Conflicts Under the Nuclear Umbrella," *RAND*, 2001.

[24]Article X, par. 1, the Treaty on the Non-Proliferation of Nuclear Weapons.

on the eve of it taking effect. This marks the beginning of ten years in which North Korea has a stockpile of plutonium in contravention of its NPT commitments—even as it engages in a series of international negotiations culminating in the 1994 Agreed Framework. The United States' withdrawal from the Agreed Framework and allegation that North Korea has nuclear weapons, culminates in North Korea restarting nuclear enrichment and ordering IAEA inspectors out of the country. In response, the IAEA Board of Governors adopt a resolution condemning North Korea's decision to restart its nuclear reactor. On January 10, 2003 North Korea announces its withdrawal from the nuclear Nonproliferation Treaty (NPT), effective January 11.[25] Iran has also been the subject of several episodes of non-compliance associated with the NPT amid concerns that Tehran's civilian nuclear industry was being used to create a clandestine nuclear weapons program. The development of Iran's nuclear program—particularly its extensive nuclear fuel cycle and enrichment capabilities—have been subject to international negotiations and a series of sanctions regimes since 2002 upon Tehran's revelation of the previously undeclared Natanz Enrichment Complex[26]. Iran's non-compliance with the existing nonproliferation regime culminated in the negotiation of the Joint Coomprehensive Plan of Action (JCPOA) in 2014 and 2015 involving Iran and the P5+1.[27] The JCPOA, designed to last twenty-five years, limits Iran's nuclear enrichment capabilities and installs an IAEA inspection regime in return for sanctions relief.[28] Following U.S. withdrawal from the JCPOA, it remains to be seen whether Iran continues to comply with the Agreement. The JCPOA, along with the Ban Treaty and the Singapore Summit documents are discussed in greater detail in Chapter 8 of this dissertation.

Each of these examples contribute to episodes of non-compliance related to the NPT from 1993-2014.

3.4 Coding Institutional Design

As noted in the previous chapters, there is considerable variation in the design of various arms control regimes. In the section below, I discuss the variables measured in the Arms Control Design Dataset v.1. A number of these variables are subsequently used in the quantitative analyses carried out in Chapter 4-7. All of the coding associated with institutional design are derived from the respective arms control treaties.

[25] As Article X requires that a country give three months notice in advance of withdrawing, this decision is particularly interesting. Rather than waiting three months, North Korea argues that it has satisfied that requirement because it originally announced its decision to withdraw in March 12, 1993, and suspended the decision one day before it was to become legally binding. This particular interpretation of international law remains untested.

[26] This complex would later be the subject of one of the only cyber attacks with kinetic consequences via the Stuxnet virus. For more on this, see Kim Zetter, *Countdown to Zero Day*, Crown Publishing, 2014.

[27] The P5+1 is comprised of the United States, Russia, China, France, United Kingdom, and Germany.

[28] Richard Nephew, "Triggers, Redlines, and the Fate of the Iran Nuclear Accord," *Arms Control Today* 47, no. 10 (2017): 21–25.

3.4.1 Arms Control Type

As noted in the previous chapters, arms control regimes address a variety of strategic problems.[29] The NPT, for example, seeks to dampen the urge of non-nuclear weapon states to proliferate, with scholars suggesting that this contributes to stability by limiting the number of states that might find themselves involved in nuclear crises and subsequent existential crises. The Hotline Treaty, too, seeks to enhance crisis stability by providing a mechanism for strategic communication between the White House and the Kremlin. As a consequence, analyses of arms control design must attempt to include the underlying arms control mission associated with the agreement itself.

Within the ACDD, there are columns for five types of arms control agreements: 1) agreements that do not attempt to "control" technology, 2) intergovernmental agreements focused on the domestic control of military technologies, 3) steps taken to ban the testing of weapon systems, 4) agreements that provide quantitative limits for specific military technologies, and, finally, 5) regimes that proscribe the development and deployment of specific military technologies. The dataset uses a series of dichotomous variables to separate agreements into each category.[30]

One of the ways to conceptualize this typology is as a continuum of control over state behavior from those agreements that do not attempt to control a military technology at all like the Hotline Agreement, to those that are focused on risk reduction and export control such as the Nuclear Suppliers Group, to those that impact weapon development in terms of testing like the Limited Test Ban Treaty discussed above, to agreements that limit the number of weapons allows in state arsenals such as START I and New START, to those agreements that prohibit the development and deployment of entire classes of weapons as the INF Treaty does.[31] I use this schema to build a variable (*TypeCat*) that scores agreements from 0 to 4 based on where they fall on this continuum.

In summary, I analyze the arms control type using both dichotomous and categorical measures. This approach is mirrored in the consideration of verification considered in the following section.

3.4.2 Verification

As with the types of arms control above, the types of verification regime examined in this section are designed to be collectively exhaustive, but it is important to note that they are

[29]Schelling and Halperin, "Strategy and Arms Control."

[30]These are noted in the following columns in the dataset *NoControl*, *Control*, *Testing*, *Limitation*, and *Prohibition*.

[31]It is worth pointing out at the outset that the analysis of various types of arms control agreement does not always easily allow for the creation of a mutually exclusive, collectively exhaustive typology given that a number of arms control regimes include a number of cross-cutting responsibilities involving states parties to the agreement. The Nuclear Nonproliferation Treaty, for example, proscribes the development of nuclear weapons in non-nuclear weapon states in Article II while also including an export control component in Article I.

rarely mutually exclusive as a large number of agreements employ a variety of institutional mechanisms to monitor and verify agreements. The INF Treaty, for example, calls for the exchange of data at the outset of the treaty framework to determine each state's stockpiles of Soviet SS-12s, SS-23s, SS-20s, SS-4s, and SS-5s and U.S. Gryphon GLCMs and Pershing-IIs followed by baseline on-site inspections followed to determine the veracity of these declarations in the three-year period of elimination with a varying number of on-site inspections allowed each year and "portal monitoring" at production facilities for a period of 13 years until the sunset of the verification regime in 2001.

For the purposes of the analysis of verification regimes, I define three categories of cooperative monitoring and verification regime analyzed in this chapter: information exchanges (*V-INF*), on-site inspection regimes (*V-OSI*), and challenge inspections (*V-CI*). There is, of course, a final category of agreements that do not specify or include a monitoring and verification regime (*NoVer*).

Loosely, we might consider these types of monitoring and verification tools on a continuum of "stringency" or "intrusiveness," though I analyze each separately before constructing and analyzing them as a categorical variable (*String*).

The dataset also includes a variable (*VerDi*) that denotes those agreements that include a verification regime like the NPT discussed above—that are scored as 1—as opposed to those that do not like the Wassenaar Arrangement—that are scored as 0.

The verification chapter also considers the types of organizations that are engaged with monitoring and verifying compliance with arms control agreements. The *V-Org* column provides the name of the verification organization, where available while *OrgDi* provides a binary score of whether a verification organization exists for the agreement (scored as 1) or not (scored as 0).

The analysis in Chapter 5 also examines how different types of verification bodies affect compliance outcomes. These verification organizations, I argue, fall into three categories that broadly reflect the membership of an agreement.

First, there are a number of agreements that have no verification organization attached to them (*NoOrg*).

Second, there are tailored institutions designed to address compliance issues related a specific treaty (*Tailored*). Tailored institutions that address implementation and compliance issues have their origins in early efforts to control nuclear arms. SALT I's Standing Consultative Commission (SCC) offers the first example of this type of institution that continues to be used today. The INF Treaty created the Special Verification Commission (SVC) charged with meeting at the request of a state party to discuss compliance issues. The SVC also played a key role in designing the on-site inspection rules and regulations that would become part of the Protocol to the Treaty outlined above. Like the INF, the New START Treaty includes the tailored Bilateral Consultative Commission (BCC) to address the practical implementation of the treaty commitments of states parties. These institutions tend to be bilateral or multilateral and have no permanent staff associated with them. These Commissions involve government officials from the governments of states parties and are often ad hoc.

Rather than the ad hoc institutions involving representatives of states parties noted above, intergovernmental organizations with professional and permanent staffs represent an alternative type of verification organization (*Intergov*). The modal example in terms of nuclear weapon programs is the International Atomic Energy Agency (IAEA), which has a role in supporting the implementation of the Nuclear Nonproliferation Treaty (NPT) via its safeguards agreements with non-nuclear weapons states. The IAEA has also been tasked with overseeing safeguards associated with various treaties related to nuclear-weapon-free zones (NWFZs) such as Central Asia Nuclear-Weapon-Free Zone (Treaty of Semei) as well as efforts to account for all nuclear material used for energy and research purposes in effort to prevent their diversion to weapons programs—e.g. Convention on the Physical Protection of Nuclear Material. The UN's 1540 Committee has also been given responsibility for the implementation of UNSC 1540 in which states are obliged to "refrain from supporting by any means non-State actors from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their means of delivery."[32] Treaty-specific organizations such as the Organization for the Prohibition of Chemical Weapons (OPCW)—the implementing body for the Chemical Weapons Convention—and the Comprehensive Test Ban Treaty Organization (CTBTO)—the implementing body for the Comprehensive Test Ban Treaty that has yet to enter into force—also serve as examples of this type of organization. These types of institutions tend to have professional staffs, a Secretariat, a budget supported by states parties, and limited integration into the broader UN system.

3.4.3 Flexibility: Sunset Mechanism

There are a variety of flexibility provisions related to agreement design including optional protocols that add to state obligations in relation to an agreement, reservations that abrogate the responsibility of a state party to a specific aspect of an agreement, escape clauses that set out a process for a state party to withdraw from an agreement, and termination clauses that designate a date on which the responsibilities of the state party to a treaty will end.

Of these flexibility provisions, some have comparatively little variation—reservations and optional protocols are exceedingly rare and escape clauses omnipresent.[33] As an example of the latter, Article XV (par. 2) of the INF Treaty reads, "Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to withdraw to the other Party six months prior to withdrawal from this Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests."

[32]UN Security Council Resolution 1540 (2004) updated in UNSC 1673 (2006), UNSC 1810 (2008), UNSC 1977 (2011).

[33]Escape clauses are often included in the penultimate or final article in an agreement and provide the process through which a state party can withdraw from an agreement.

The existence of termination clauses, however, vary both in terms of their inclusion and in terms of their length among arms control agreements. In ACDD v.1, I include two variables related to termination clauses or sunset mechanisms. The first is a dichotomous measure (*SunDi*) that codes the presence or absence of a termination clause. Where present, I also include a variable that measures the amount of time until the termination occurs (*TimetoSunset*).

3.4.4 Membership

I use two different criteria for coding membership of agreements. The first borrows from Vaynman's doctoral work that splits agreements into those that are bilateral (involving two states parties), minilateral (involving three to nine states parties), and large multilateral agreements (involving 10 parties or more).[34] Each of these types of membership associated with an arms control agreement are provided their own column in the analysis: *Bilateral*, *SmMulti*, and *LgMulti*. The dataset also includes a column that tracks the number of parties (*NumParties*) in an agreement that occasionally varies while an agreement is in force.

The second criterion draws a dichotomous distinction between those agreements that are bilateral and those are multilateral (involving three or more states parties) using a scored dichotomous variable (*Multilateral1*). It is worth pointing out that as the dataset is composed of agreement-years, there are agreements that transition between the categories. START I, for example, negotiated between the United States and Soviet Union, was multilateralized by the Lisbon Protocol upon the dissolution of the USSR to address the 3,000 strategic nuclear weapons and 3,000 tactical nuclear weapons deployed within the newly independent states of Belarus, Kazakhstan, and Ukraine—increasing the number of states parties to the Treaty from two to five. COCOM, the Nuclear Suppliers Group, and Missile Technology Control Regime also steadily increased their respective numbers of states parties during the period covered by the dataset.

Among those frameworks included in the dataset, there is one case that does not fall simply into a coding criteria. I code the Mongolian Nuclear Weapons Free Zone—in which the Mongolian government unilaterally declared that the government would not pursue nuclear weapons technology—as a multilateral agreement in the dataset following the recognition of this status by the United Nations.[35]

[34]Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries." It is worth noting that the definition of minilateralism varies beyond the methodological choice made here as regimes and cooperative frameworks that include up to 30 states are occasionally described as being minilateral. For the purposes of the ACDD, I use a range of three to nine states in order to compare my analysis and findings with previous work.

[35]This status is enshrined within UN documents: A/55/56 S/2000/160.

3.4.5 Control Variables

The analysis also includes a number of additional columns collected to serve as control variables for the analysis or to be of use in future work. The first set of these variables are those coded by Kreps concerning the obligation, delegation, and precision of agreements. These categorical variables are constructed by scoring each agreement in terms of its institutional design parameters:
`Obligation`—Degree of agreement's binding nature:

- 0 for "gentleman's handshake";
- 1 for formally binding;
- 2 for no reservations, declarations, understandings; and
- 3 no escape clauses.

`Precision`—Specificity of requirements embedded in agreement:

- 0 for aspirational in terms of numbers, behavior, timelines;
- 1 for specificity in terms of arms control behavior (e.g., action required on testing, whether states can develop weapons or not); and
- 2 for specificity in arsenal numbers, thresholds, delivery vehicles, timelines for reaching objectives.

`Delegation`—Degree to which states assign authority for the enforcement of the agreement to third parties:

- 0 for no outside agency delegation, inspections, or specified monitoring;
- 1 for reporting of compliance through regular meetings or information exchanges;
- 2 for monitoring through states National Technical Means; and
- 3 for verification through on-site inspections.

[36]

I include these variables to engage with prior work on the institutional design characteristics of arms control agreements and also to offer an alternative (and hopefully, clearer) treatments of institutional design variables that avoid mixing different types of verification regime as is the case with the *delegation* variable above.

The ACDD also includes a binary measure of whether an agreement-year falls into the Cold War period (*ColdWar1*) and a dichotomous measure of whether an agreement-year

[36] Kreps, "The institutional design of arms control agreements."

represents a follow-on arms control agreement (*Successor1*) as is the case with New START following on from START I.

In addition to the variables used in the analysis to follow, the ACDD includes a column that denotes whether the agreement in question serves as an example of adversarial cooperation (*Adverserial1Non0*) per Vaynman's definition of the term.[37] It also includes a column for future analysis to compare nuclear arms control against non-nuclear examples (*Nuc1Non0*) and a continuous variable that tracks how long it takes for agreements to be negotiated (*NegotiationTime*)

For use as an alternative outcome variables, the ACDD also includes global nuclear arms data from the Nuclear Notebook (*OverallNukes*).[38] A subsequent version of the ACDD that includes country-agreement-year will also include country-level nuclear arms data.

3.5 Quantitative Approach

Ideally, an analysis of the variation of institutional design upon compliance would analyze all instances of arms control frameworks in the context of state behavior. To do this, I use longitudinal panel data including information concerning all design characteristics associated with arms control regimes for all arms control agreement-years and country-agreement-years would represent the independent variable. This would then be used in an analysis of the dependent variable, in this compliance, to determine their relative effects.[39] In the section to follow, I provide descriptive statistics and describe the analytic approach taken to quantitative assess the effects of institutional design, primarily using probit regression methods.

3.5.1 Probit Modeling Approach

Probit—and logistic—models can be used for modeling the relationship between one or more numerical or categorical predictor variables and a categorical outcome. Both require that outcome variables be coded as 0 or 1. As noted above, the *Compliance1* variable used in this study is coded as such (with 1 denoting a compliance agreement-year and a 0 denoting non-compliance agreement-year).[40]

[37]Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

[38]Hans M Kristensen, "Global Nuclear Arsenals, 1990–2018," in *Nuclear Safeguards, Security, and Nonproliferation* (Elsevier, 2019), 3–35.

[39]Gary King, Michael Tomz, and Jason Wittenberg, "Making the most of statistical analyses: Improving interpretation and presentation," *American Journal of Political Science*, 2000, 347–361; Michael A Bailey, Anton Strezhnev, and Erik Voeten, "Estimating dynamic state preferences from United Nations voting data," *Journal of Conflict Resolution* 61, no. 2 (2017): 430–456; Arthur S Banks and Kenneth A Wilson, "Cross-National Time-Series Data Archive," *Databanks International*, 2013, Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements."

[40]Using an alternative Ordinary Least Squares (OLS) regression model is arguably inappropriate for models that include binary outcome variables as they can violate assumptions associated with the distribution

In generalized linear models, instead of using Y as the outcome, I use a link function of the mean of Y.

$$\hat{Y} = f(\alpha + \beta x) \tag{3.1}$$

in which $\hat{Y}$ represents compliance and β represents the design characteristics examined in this chapter.

For the link function for a probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors. The coefficients produced in the estimation of the probit model represent the change in the Z-value for a one-unit change in the independent variable (in this case the presence or absence of a specific institutional design parameter). Because the probit uses a nonlinear function (the inverse standard normal distribution) to derive these coefficients, this distribution can subsequently be used to calculate the predicted probability of compliance given particular institutional designs based on the empirical record.[41] This approach also allows to calculate the marginal effects of the variable of interest. As an example, I can compare the predicted probabilities of compliance between those agreements that are bilateral versus those that are not.[42]

Probit models can also account for the effects of co-variates by including them in the model. When calculating the predicted probability of the independent variable of interest against the outcome variable, however, the researcher faces a choice concerning how to treat the co-variates—whether holding them at their mean or at specific values.[43] Generally speaking, I hold co-variates at their mean value except when considering specific institutional designs.

The "quantitative analysis" sections in each of the subsequent chapters outlines the respective processes of calculating the probit model coefficients and the predicted probabilities of compliance given the specific independent variables of interest. Each chapter also includes a "sensitivity analysis" that considers the multicollinearity, homoskedasticity, and independence in the data.

To address this, I use heteroskedastic probit models and a comparison of the standard errors and coefficient estimates provided by these models to assess whether the non-independence of data points for the outcome variable or the regressors are a concern in each of the analysis chapters to follow.

Alternative specifications that might also be used to address concerns surrounding the independence of the data in the ACDD include fixed effect logistic and probit regression,

of errors. Recent scholarship, it is worth noting, has called this supposition into question and has led to some debate in the methods literature: Atanu Biswas, Samarjit Das, and Soumyadeep Das, "OLS: Is That So Useless for Regression with Categorical Data?," in *Advances in Analytics and Applications* (Springer, 2019), 227–242.

[41] I use this particular feature of the probit model in each of the quantitative chapters and to consider arms control regimes not included in the ACDD in chapter 8.

[42] The analysis of membership is the subject of chapter 7.

[43] This feature of the probit models built on the empirical data provided by the ACDD allow for a calculation of the predicted probability of compliance in any given year for new arms control frameworks.

mixed effects logistic and probit regression that model both binary outcomes and can include random and fixed effects, and logistic regression with clustered standard errors.[44]

Throughout the sensitivity analyses, I find that the non-independence within the data are negligible with the heteroskedastic probit model results (denoted by an HP after the Model name) reported in each chapter.

3.5.2 Time Dependence

I also test whether the cross-sectional panel data considered in this analysis involving the ACDD is temporally dependent in an effort "to take time seriously" as both a confounder and driver of arms control outcomes. As Beck et al. note, if observations are temporally related then the results provided by the standard probit and logit modeling approaches described above may be misleading.[45] To address this, I use Carter and Signorino's cubic polynomial approximation method that includes measures of time—t, t^2, and t^3—in the regression.[46] In the analysis, t is the time since the last event.[47] In this analysis, the event at issue is a breach of an arms control agreement (t represents the time since the last event—that is, a breach of the agreement).[48] Perhaps unsurprisingly given that arms control outcomes in one period are likely related to arms control outcomes in previous periods, the analysis in the subsequent chapters shows that temporal dependence does have varying and marginal effects on the findings presented in the dissertation.

The full results of the cubic polynomial approximations are included in the sensitivity analysis sections to follow. Throughout, I run the analyses on those models that best address the research findings described in the chapter. Usually, this involves re-assessing the independent variable of interest alone before carrying out an analysis including design and non-design control variables.

3.5.3 Selection Issues

As Downs et al. and von Stein have noted, analysis of observational data (and treaty data, specifically) should consider selection effects in terms of causal inference.[49] In simplest terms,

[44]More complex models might also be used to address concerns over the temporal dependence of the results including the recent cubic polynomial approximation process described by Carter and Signorino—though these are best suited to time-series and survival analyses.David B Carter and Curtis S Signorino, "Back to the future: Modeling time dependence in binary data," *Political Analysis* 18, no. 3 (2010): 271–292.

[45]Nathaniel Beck, Jonathan N Katz, and Richard Tucker, "Taking time seriously: Time-series-cross-section analysis with a binary dependent variable," *American Journal of Political Science* 42 (1998): 1260–1288.

[46]Carter and Signorino, "Back to the future: Modeling time dependence in binary data."

[47]Carter and Signorino explain the process of defining t on page 3 of the supplementary materials associated with the article: ibid.

[48]The cubic polynomial approximation procedures offers several advantages in terms of performance, simplicity, and interpretability compared to time dummy and spline-based alternatives.

[49]George W Downs, David M Rocke, and Peter N Barsoom, "Is the good news about compliance good news about cooperation?," *International Organization* 50, no. 3 (1996): 379–406; Jana Von Stein, "Do treaties

any outcome variables (in this case, compliance) must be measured against the predilection of a state to take the same action in the absence of the variable of interest (in this case arms control agreement design). It may also be the case that the variables driving the very creation of an agreement with a particular design at the outset are also driving a state's decision to comply or not to comply with an agreement.

There are several potential approaches to addressing selection effects—though some suggest that overcoming these selection issues are unlikely to be overcome statistically by using available methods.[50] One existing method used to address this issue is the use of propensity scores, a statistical matching technique used to estimate the effect of a treatment variable (in this case an agreement with a termination clause) by accounting for co-variates that predict receiving the treatment.[51] More recently, Lupu's spatial model synthetic matching technique offers another example of statistical matching methods applied to the challenges posed in examining international agreements.[52]

Selection models offer an alternative, two-step statistical means of correcting for non-randomly selected samples by treating the selection problem as an omitted variable problem in which a first-stage probit equation estimates the selection process, and the results from that equation are used to construct a variable that captures the selection effect.[53] To do this in the context of states signing onto an agreement, however, requires a country-agreement-year cut of the ACDD in which correlates of countries signing an agreement can be used to calculate whether the independent variable of interest affects state behavior.[54]

While it is possible, in principle, to further address selection bias by including arms control agreements that were signed and did not enter into force—as well as arms control agreements that were proposed but never negotiated, there would be significant concerns regarding whether these arms control regimes that never enter a prototype phase are known to researchers in a systematic, unbiased manner.[55]

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constrain or screen? Selection bias and treaty compliance," *American Political Science Review* 99, no. 4 (2005): 611–622.

[50]Gary King and Richard Nielsen, "Why propensity scores should not be used for matching," *Political Analysis*, 2016, 1–20; Sander Greenland, Judith A Schwartzbaum, and William D Finkle, "Problems due to small samples and sparse data in conditional logistic regression analysis," *American Journal of Epidemiology* 151, no. 5 (2000): 531–539.

[51]Simmons and Hopkins, "The constraining power of international treaties: Theory and methods"; Simmons, "Treaty compliance and violation."

[52]Yonatan Lupu, "The informative power of treaty commitment: using the spatial model to address selection effects," *American Journal of Political Science* 57, no. 4 (2013): 912–925.

[53]James J Heckman, "The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models," in *Annals of Economic and Social Measurement, Volume 5, number 4* (NBER, 1976), 475–492.

[54]This approach offers the added advantage of addressing domestic-level factors that might influence state behavior.

[55]This problem is particularly acute given the secrecy surrounding the existence and contours of arms control debates between states in bilateral and multilateral contexts. As Kreps points out based on an interview with James Goodby—a negotiator of the Limited Test Ban Treaty—strategic need and the decision to undertake arms control "determine appropriate legal contours... not vice versa." Kreps, "The institutional

Conditional on an agreement entering into force, the analysis presented in this dissertation evaluates why some agreements have higher or lesser predicted probabilities of compliance based on their design characteristics given an analysis of those nuclear arms control agreements included in the ACDD. In future work, a country-agreement-year treatment of the data in the ACDD will most appropriately allow for the use of both matching protocols and selection models to estimate the causal effects from the observational data provided by the the cases included in the ACDD.[56]

Thus, the findings presented in the dissertation have the caveat, common among observational studies, that they provide a first cut at the causal relationship between institutional design characteristics and compliance outcomes on an agreement-year basis.

3.6 Qualitative Approach

Alongside the quantitative approach noted above, I engage with a number of empirical cases of arms control from the Arms Control Design Dataset as well as a few cases that are not included in the dataset both to underline where the quantitative analysis is in line with existing cases and where there may be exceptions to the general pattern described in the modeling approaches. Arms control regimes that are explored in-depth include the INF Treaty in Chapter 5 and the NPT in Chapter 7. In Chapter 8, I reflect on the analysis carried out in the quantitative chapters and use the ACDD as training data to assess a numbre of contemporary arms control issues: the JCPOA and the Treaty on the Prohibition of Nuclear Weapons (also known as the "Ban Treaty").

3.7 The Arms Control Design Dataset in Practice

In the chapters to follow, the variables described described above are used to reflect on patterns of compliance given the various types of arms control challenges that agreements are designed to address, what types of verification regimes are used to monitor and verify agreements, whether including termination clauses to arms control agreements has the intended effects, and whether including more parties in an agreement makes a difference to patterns of compliance. In the process, the chapters engage with conventional wisdom concerning which types of designs are "best" and examine whether these are, in fact, borne out in the data.

design of arms control agreements"

[56] A country-agreement-year treatment will allow for regressors correlated with a state's decisions to enter an agreement in the selection equation separate from those regressors that are predicted to affect a state's decision to comply with an arms control agreement, or not.

Part II

Analysis

Chapter 4

The Dangers of Doing More: How Agreement Type Affects Compliance

Abstract

Among the myriad frameworks designed to control arms, there is considerable variation in their design—particularly in terms of their scope, membership, and flexibility. The causes and consequences of this variation, however, remain unexplained. In this chapter, I use the original "Arms Control Design Dataset" (ACDD) that tracks design characteristics of arms control regimes on an agreement-year basis to examine the effect of arms control agreement type—from test bans to arms limitation agreements—on compliance. In the process, I also point to a number of empirical examples that vary in terms of this typology including the Limited Test Ban Treaty, SALT Interim Agreement, START I, INF, and New START as well as discussing the consequences of the analysis for future arms control agreements beyond nuclear weapons.

4.1 Introduction

Are states more likely to comply with agreements designed to limit arms testing compared to those that attempt to proscribe the development and deployment of entire classes of weapons? How about agreements designed to limit the numbers of armaments in state arsenals?

On one hand, export control or test bans that do not impinge upon the ability of states to continue weapons development may be "easier" for states to comply with than agreements that limit or proscribe weapons development given the relatively low opportunity costs associated with foregoing nuclear testing compared to the years required to develop and deploy weapon systems. On the other, having weapons in an arsenal means the opportunity to test remains omnipresent, potentially increasing domestic calls to perform testing to maintain the arsenal. Given the potential for compliance outcomes to be shaped by the

character of strategic problems that the arms control agreement is attempting to address, analyzing the underlying arms control challenge associated with an agreement represents an important—and under-explored—issue for scholarly inquiry.

In this chapter, I consider the variation in compliance outcomes across four types of arms control agreement. First, those agreements that prohibit the development and deployment of military technologies. Second, those agreements that limit the number of arms in state arsenals. Third, those agreements that limit the testing of military technologies. And, finally, intergovernmental agreements designed to promote domestic control of military technologies via export control and risk reduction measures. In the process, I answer the following empirical question:

- Does the underlying scope of the arms control agreement influence the likelihood of compliance with the agreement?

In the following sections, I create a typology of arms control agreements before carrying out an empirical examination of how compliance outcomes reflect the varying goals of agreements using a series of regression models. In the process, I engage with existing theoretical work concerning export control, test bans, arms limitation agreements, and ban treaties. I conclude by reflecting upon how these lessons might apply to contemporary debates concerning the appropriateness of using intergovernmental regulatory regimes to address emerging technologies in general, and artificial intelligence in particular.

4.2 The Effect of Arms Control Type on Compliance

In this section, I draw on the theoretical debates discussed in depth in Chapter 2 to consider how existing realist, utilitarian, and normative theories concerning international cooperation and arms control might be usefully parsed in a discussion concerning the type of arms control agreement and its attendant impact upon patterns of compliance with the agreement.

4.2.1 Epiphenonemal Arms Control

Perhaps the most well-known approach to international cooperation—of which arms control is an example—from the realist canon comes from the work of John Mearsheimer in which he writes that "institutions have minimal influence on state behavior and thus hold little prospect for promoting stability in a post-Cold War world."[1] Scholars of the realist tradition remain skeptical of the utility of treaties and international law in driving state behavior absent an associated coercive apparatus that reflects existing inter-state power dynamics—regardless of their purpose. For example, Valentino, Huth, and Croco contend that "whatever pressures toward restraint these treaties may exert on their signatories appear to be overwhelmed by the strategic incentives that combatants face to prevail and limit

[1] Mearsheimer, "The false promise of international institutions."

the costs of war to their own citizens."[2] Francis Gavin, too, suggests that "identifying the nuclear arms race as the driving force behind the Cold War—instead of the geopolitical and ideological conflicts between the Soviet Union and the United States—has led many analysts to overstate the importance of arms control treaties and regimes, both in the past and today."[3] In scholarship examining disarmament as a condition of victory, Betts argues that the "main problem is the gap between the instinctive appeal of the idea [of arms control] in liberal cultures as they settle epochal conflicts, and its inherent defects in relations among independent states as they move from peace toward war."[4] Realist scholars have also argued that scholars and policy-makers promoting arms control as a cause of peace have the causal arrow moving in the wrong direction and that peace, in fact, drives the creation of arms control regimes. They go on to ask the question: "were, then, the agreements necessary? Many of the [arms] reductions would have happened anyway, particularly in conventional forces..."[5] This perspective suggests a null hypothesis in which:

- H_0: There is no pattern concerning types of arms control agreements and compliance.

With that said, some scholars within the realist tradition treat arms control as a useful but ultimately peripheral process that can reduce the costs and risks of competitive security policies at the margins.[6] They might expect, for example, arms control agreements that require a smaller shifts from state preferences to be more likely to succeed compared to those in which state interests are at odds with a treaty. This argument, to some extent, is also reflected in the contention of institutionalist scholars concerning how the scope of an agreement is likely to shape outcomes discussed below.

4.2.2 Utilitarian Considerations

In contrast to the approaches that view arms control as epiphenomenal, utilitarian scholars suggest that cooperative institutions—even among adversaries—offer states a pathway toward the desired end and that state preferences become baked into cooperative frameworks during the negotiation phase. A number of scholars, for example, have examined the trade-offs that states pursue in bargaining.[7] They further argue that cooperative frameworks reflect rational calculations regarding material interest: "treaties are signed on the basis of

[2]Valentino, Huth, and Croco, "Covenants Without the Sword International Law and the Protection of Civilians in Times of War."

[3]Gavin, "Same As It Ever Was: Nuclear Alarmism, Proliferation, and the Cold War."

[4]Betts, "Systems for peace or causes of war? Collective security, arms control, and the new Europe."

[5]Bohlen, "The rise and fall of arms control."

[6]Jervis, "Cooperation under the security dilemma."

[7]Charles Lipson, "Why are some international agreements informal?," *International Organization* 45, no. 4 (1991): 495–538; Fearon, "Bargaining, enforcement, and international cooperation." Some scholars suggest that states pursue their interests strategically and use multilateral institutions when unilateral actions are unavailable or unlikely to have the desired effect.

material cost-benefit calculations."[8] Koremenos, Lipson, and Snidal, for example, suggest that regime design and attempts to change regimes represent the sum of rational, utilitarian, and purposive interactions among states. They argue that "states use international institutions to further their own goals, and they design institutions accordingly."[9] In a similar vein, Keohane and Martin suggest that "when states can jointly benefit from cooperation we expect governments to attempt to construct such institutions."[10] What are these benefits? "Institutions can provide information, reduce transaction costs, make commitments more credible, establish focal points for coordination, and in general facilitate the operation of reciprocity."[11] Recent work, adding to previous research concerning institutional nesting, has also pointed to the importance of the "institutional context" in which new agreements are embedded—as well as the existing and prior agreements among prospective partners in a "new" agreement.[12]

This theory suggests that the underlying strategic challenge becomes an intrinsic characteristic embedded within the design of the agreement. An optimistic reading of this theory might suggest that these design characteristics might overcome compliance challenges associated with more difficult agreements by virtue of the design choices associated with each type of agreement.

- H_1: Overall patterns of compliance among agreements should remain similar regardless of the type of agreement negotiated by states parties.

A more pessimistic proposition might suggest that compliance outcomes are baked into the strategic dilemma that an arms control regime is designed to address, and that while design characteristics might soften the likelihood of noncompliance, it remains a "hard" problem that is likely to result in variance in relative performance based on agreement type.

- H_2: Compliance with an arms control agreement may vary based on the strategic challenge that it is designed to address.

It is also worth noting that scholars from the neo-liberal institutionalist perspective may also expect more overall compliance with arms control agreements than the realist scholars noted above, given their contention that agreements are designed to maximize compliance. While violations of an agreement only occasionally lead to regime collapse, rationalist scholars—and anecdotal evidence from policy-makers involved in arms control negotiations—suggest that compliance represents a central concern of regime participants.

[8]Hansen, "Taking ambiguity seriously: Explaining the indeterminacy of the European Union conventional arms export control regime"; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[9]Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[10]Keohane and Martin, "The promise of institutionalist theory."

[11]Ibid.

[12]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Copelovitch and Putnam, "Design in context: existing international agreements and new cooperation"; Kahler, "Evolution, choice, and international change."

4.2.3 Arms Control and Logics of Appropriateness

Scholars engaged in debates concerning the appropriateness of researching, building, and deploying specific types of military technologies, on the other hand, suggest that arms control represents the outcome or manifestation of a shift in the logic of appropriateness concerning the development and deployment of specific military technologies among states. Some scholars suggest that this process represents a "social process" among states. In simple terms, they argue that specific types of weapons systems have become normatively undesirable and that this has led to a "taboo" against their use.

With regard to weapons bans, in particular, constructivist scholars describe the eradication of specific classes of weapon technology in normative rather than strategic terms. Price, for example, tracks the genealogy of efforts to ban and eradicate chemical weapons in a study of mustard gas and nerve agents. Tannenwald, too, describes efforts to ban nuclear weapons and the development of opposition to nuclear weapons in normative terms. This opposition, she argues, is central to the non-use of nuclear weapons since the attacks on Hiroshima and Nagasaki. In both cases, the concept of a "taboo" has been used to describe state compliance with a variety of norms related to the banning of weapons of mass destruction.[13]

What normative theory does allow for is an explanation of arms control outcomes on the basis of the types of agreement. Efforts to eradicate the development and deployment of entire categories of weapons may be more likely to lead to compliance given the normative prohibition than those arms control regimes that are focused on constraining the circumstances under which certain military technologies might be used or the numbers of a particular weapon allowed in state arsenals.

This reflects a specific set of hypotheses concerning the direction of compliance outcomes associated with the underlying strategic dilemma that an arms control regime is designed to address:

- H_3: Prohibition agreements should be more likely to yield compliance than efforts to limit or otherwise control military technologies.

Indeed, this chapter focuses on reflecting on a puzzle noted by Keck and Sikkink in 2014: "[the] socialization literature theorizes the diffusion of norms over time and space, but it is still puzzling as to why some norms seem to be internalized and complied with more than others."[14]

[13]Tannenwald, "The nuclear taboo: The United States and the normative basis of nuclear non-use"; Tannenwald, "Stigmatizing the bomb: Origins of the nuclear taboo"; Price, "A genealogy of the chemical weapons taboo." Work on landmines and small arms have followed in this vein suggesting that norms against military technology are "institutionalized in arms control regimes.Garcia, *Small arms and security: new emerging international norms*

[14]Keck and Sikkink, *Activists beyond borders: Advocacy networks in international politics.*

4.3 A Typology of Arms Control

As noted in the previous chapters, arms control regimes address a variety of strategic problems.[15] The NPT, for example, seeks to dampen the urge of non-nuclear weapon states to proliferate, with scholars suggesting that this contributes to stability by limiting the number of states that might find themselves involved in nuclear crises and subsequent existential crises. The Hotline Treaty, too, seeks to enhance crisis stability by providing a mechanism for strategic communication between the White House and the Kremlin. As a consequence, analyses of arms control design must attempt to include the underlying raison d'être associated with the agreement itself. In the section to follow, I consider international efforts focused on the domestic control of military technologies, steps taken to ban the testing of weapon systems, agreements that provide quantitative limits for specific military technologies, and, finally, regimes that proscribe the development and deployment of specific military technologies. One of the ways to conceptualize this typology is as a continuum of control over state behavior from those agreements that do not attempt to control a military technology at all—like the Hotline Agreement—to those that are focused on risk reduction and export control, to those that impact weapon development in terms of testing, to agreements that limit the number of weapons allows in state arsenals, to those agreements that prohibit the development and deployment of entire classes of weapons.[16] In the section below, I describe the four types of arms control agreements that might fit on such a continuum for use in the empirical analysis to follow.

4.3.1 Technology Control

In this section, I discuss multilateral export control and risk reduction measures related to specific military technologies, in turn. For the purposes of creating a useful typology for analysis, I classify these arms control measures as "technology control." The distinguishing characteristic of this type of arms control is that it is non-binding and often described as "soft law."

Export control refers to national efforts to restrict the transfer of equipment, software, and technology designated by the state as having implications for national security or foreign policy. There are a number of factors that states use to determine whether a specific technology falls into these categories, including the potential impact of the technology upon the proliferation of WMD, the consequences of the technology upon regional stability, hu-

[15]Schelling and Halperin, "Strategy and Arms Control."

[16]It is worth pointing out at the outset that the analysis of various types of arms control agreement does not easily allow for the creation of a mutually exclusive, collectively exhaustive typology given that a number of arms control regimes include a number of cross-cutting responsibilities involving states parties to the agreement. The Nuclear Nonproliferation Treaty, for example, proscribes the development of nuclear weapons in non-nuclear weapon states in Article II while also including an export control component in Article I.

man rights as well as other ethical considerations, and international commitments vis à vis sanctions regimes.

The Coordinating Committee for Multilateral Export Controls (COCOM), Nuclear Suppliers Group (NSG), Australia Group, Missile Technology Control Regime (MTCR), and the Wassenaar Arrangement each serve as prototypical examples of intergovernmental export control regimes. Each of these institutions comprises varying numbers of states that contribute to lists of controlled technologies that domestic agencies are then tasked with regulating. The Nuclear Suppliers Group, for example, has sought to control the spread of nuclear technology to states outside of the existing nuclear safeguards regime via its guidelines in the Zangger "Trigger" List (INFCIRC/254) and "Dual Use" List that banned the transfer of technology that represents a proliferation risk—growing from an original seven members in 1975 when it was created in response to India's first nuclear test to 48 member states in 2017. The Australia Group—an informal, select grouping of states—was created in 1985 by 15 states as a response to Iraqi use of chemical weapons to prevent the export of chemical precursors used in the production of chemical and biological weapons. Currently, the Australia Group's 43 states regulate the export of 54 compounds, a number of which are not explicitly mentioned in the Chemical Weapons Convention. The MTCR, established in 1987, addresses missile technology and associated delivery systems. The goal of the regime is to prevent the proliferation of technology that allows for 500 kilogram payloads to be carried more than 300 kilometers. The Wassenaar Arrangement, a follow-on arrangement of the Coordinating Committee for Multilateral Export Control (CoCom), offers an information-sharing regime associated with conventional military technologies including tanks, military aircraft, warships, missile systems, small arms, and, increasingly, Internet technology. These arrangements attempt to provide supply-side constraints on military technology.

As well as export control mechanisms, there are a number of risk reduction regimes designed to address other aspects of domestic policy—usually concerning nuclear technology. The Nuclear Terrorism Convention, for example, outlines a series of best practices for states to follow regarding the protection of nuclear power plants, sharing information regarding terrorist threats involving nuclear weapons, and liaising with the IAEA to address crises. The Proliferation Security Initiative similarly attempts to address the trafficking of WMD materials and their associated delivery vehicles using domestic arrangements.

4.3.2 Testing Constraints

Rather than curbing exports—or limiting weapons numbers—testing constraints govern whether and in what venues states can test specific military technologies.

The existing testing regime arose amid concerns surrounding the role of nuclear tests in nuclear proliferation as well as environmental concerns related to nuclear testing. The Limited Test Ban Treaty (LTBT), Threshold Test Ban Treaty (TTBT), and Comprehensive Test Ban Treaty (CTBT)—the latter having not entered into force—serve as examples of these types of arms control arrangements. The LTBT entered into force in 1963 and banned atmospheric, underwater, and space-based testing. It does not, however, prohibit underground

testing.[17] Reflecting the arms control debates that would follow, the test ban negotiations that began in 1955 failed to address the question of how to verify compliance with the agreement. The United States, fearing clandestine violation of any agreement (with particular concerns about underground testing) did not want to create an uncontrolled regime. There were also disagreements concerning the organization of a "Control Commission" to administer inspections and organize "control posts" in each nuclear state and in the Pacific Ocean, the number of permitted on-site inspections of each state, and the role of a veto over the normal operation of the arms control regime. These disagreements reflected early debates over the design of verification in subsequent arms control regimes discussed in later chapters of this dissertation. The parties were unable to address these concerns, and the LTBT was signed without a verification mechanism. These concerns concerning design, verification, and compliance would later affect Threshold Test Ban Treaty (TTBT) negotiations.[18] Following the end of the Cold War, states revisited discussions surrounding a comprehensive ban on nuclear testing—the Comprehensive Test Ban Treaty (CTBT). To facilitate these discussions, the Comprehensive Test Ban Treaty Organization (CTBTO) was created in Vienna, Austria in 1996.

Despite the CTBT not entering into force (at the time of this writing), the CTBTO is already in the process of creating a series of verification mechanisms to prepare for the CTBT's entry into force. The first is an international monitoring system that includes seismic, hydroacoustic, infrasound stations that provide oceanic and underground monitoring as well as radionuclide stations designed to detect radioactive debris. The CTBTO is also empowered by the draft treaty to engage in state consultation/clarification, on-site inspections, and to create confidence-building measures among states parties.[19]

While it might be easy to consider the creation of a nuclear testing regime as representing a fairly low-cost method of arms control, the implementation of nuclear test bans have consequences for the reliability of strategic weaponry, as the plutonium and uranium pits in warheads degrade, leading to concerns that the U.S.-Russian testing moratorium from 1991 may affect efforts to modernize U.S. nuclear forces.[20] As this dissertation goes to print in 2019, the U.S. Defense Intelligence Agency noted that "the U.S. Government, including the Intelligence Community, has assessed that Russia has conducted nuclear weapons tests that have created nuclear yield."[21]

[17]With regard to compliance, and reflecting the importance of translating draft agreements appropriately, there were a series of U.S. allegations in the early 1960s that the Soviets were in breach of the Treaty due to nuclear material from underground weapons tests crossing the Soviet border. These allegations were driven, in part, by a failure to agree upon the definition of *debris* in the agreement text.

[18]According to U.S. press reports in the 1970s, three underground tests (among the estimated 27 carried out by the Soviet Union) are believed to have violated the 1974 TTBT and its 150-kiloton ceiling on tests and another 13 tests in 1978 involving illegal "venting" of radioactive material—including krypton and other fission products—into the atmosphere.

[19]The United States, China, India, Pakistan, DPRK, Iran, Israel, and Egypt have not ratified the CTBT and all eight are required to sign and ratify the treaty before its entry into force.

[20]Author Interview, February 2019.

[21]Defense Intelligence Agency Statement of June 13, 2019. Available at:

4.3.3 Arms Limitations

Arms control frameworks that involve arms limitations attempt to provide an upper-bound *number* of weapons of a particular type that states must adhere to. Both the SALT and START frameworks serve as examples of these types of arms limitation agreements in the nuclear domain, while the 1923 Washington Naval Treaty that sought to asymmetrically limit the construction of battleships, battlecruisers, and aircraft carriers serves as a historical non-nuclear example.[22] Below, I provide a brief account of efforts by the United States and USSR to limit the number and type of strategic weapons that serve as examples of this type of agreement.

Alongside the multilateral discussions in the early 1960s that resulted in the LTBT agreement discussed above, the United States and USSR were engaged in contemporaneous efforts to arrest the production of fissile material and limit the number of strategic nuclear weapons leading to the U.S.-Soviet SALT I Interim Agreement signed and entered into force in 1972 alongside the Anti-Ballistic Missile (ABM) Treaty. SALT I represented the first attempt to limit strategic offensive arms between the U.S. and USSR during the Cold War and froze the number of fixed land-based ICBM launchers and ballistic missiles on submarines. The original agreement, slated to sunset in October 1977, was extended indefinitely by both parties.

The SALT II Agreements negotiated throughout the 1970s and signed by the United States and USSR in 1979 set a ceiling of 2,400 ICBM launchers, SLBM launchers, heavy bombers, and air to surface ballistic missiles (ASBMs). This ceiling was to be reduced to 2,250 by January 1981. Despite both parties initially abiding by the Agreement, the treaty never entered into force and was invalidated by the United States exceeding the limits of the Agreement by deploying a new heavy bomber equipped with long-range cruise missiles in 1986. Following SALT I and the SALT II Treaty that never entered force, the Treaty on the Reduction and Limitation of Strategic Offensive Arms (START I) negotiations following the end of the Cold War called for gradual reductions in the arsenals of both parties to 1,600 strategic nuclear delivery vehicles and 6,000 "accountable" warheads. This amounted to an approximately 50 percent decrease in ballistic missile warheads available to each side.

For some types of military technologies, however, efforts to curb their numbers have been considered inadequate. This has led to efforts to proscribe their development, deployment, and use. Of these, the Treaty on the Prohibition of Nuclear Weapons, colloquially known as the "Ban Treaty," serves as just the most recent example. The section below considers a number of efforts undertaken by states to ban the development and/or deployment of certain military technologies.

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https://www.dia.mil/News/Speeches-and-Testimonies/Article-View/Article/1875351/dia-statement-on-lt-gen-ashleys-remarks-at-hudson-institute/

[22]The Washington Naval Treaty is particularly interesting given the potential return of asymmetrical arms control following recent developments surrounding intermediate range ballistic missiles, concerns surrounding the extension of New START in 2021, and the development of non-strategic nuclear weapons—including hypersonic weapons.

4.3.4 Prohibition

At the outset of this section, it is important to re-emphasize the conceptual distinction between disarmament and arms control. While disarmament represents the practice of taking a military technology out of a state's arsenal and often reflects moral sentiments concerning the appropriateness of a weapon system, arms control practices are more varied and reflect a strategic calculation among states parties. Trachtenberg, for example, argues that arms control on occasion is about ensuring the successful use of a military technology rather than taking it off the table.[23] He notes, "a retaliatory capability as something to be enhanced, not degraded—something to be made more secure, less accident-prone, less in need of striking quickly to avoid its own destruction, less capable of gaining advantage from a sudden attack."[24] Schelling, specifically, suggests that "it could be an open question whether we ought to be negotiating with our enemies for more arms, less arms, different kinds of arms, or arrangements superimposed on existing armaments."[25] Bull in *The Control of the Arms Race* also notes the potential for the practice of arms control without disarmament. Put simply, arms control is inclusive of disarmament but not restricted to it.[26] In this section, I provide two examples of efforts to prohibit the development and deployment of military technologies, one concerning nuclear weapons—the bilateral INF Treaty—as well as a non-nuclear example—the multilateral Chemical Weapons Convention that followed the 1925 Geneva Protocol.

The INF Treaty was designed to address the gap in the regulation of nuclear weapons in the SALT framework that limited only the number of long-range ballistic missiles. This regulatory gap led the USSR, in particular, to develop and deploy SS-20 missiles of intermediate range (with ranges of 3,000-5,500 kilometers). These missiles led to concerns on the part of European states and the United States that European states were at risk from the Soviets achieving a fait accompli in the region before NATO forces would be mobilized to respond. Unlike the SALT provisions, however, the INF Treaty negotiations focused on the elimination of an entire class of weapons—intermediate range missiles (IRMs) and shorter-range missiles (SRMs)—from state arsenals in a quid pro quo arrangement. The Treaty also banned the flight-testing and production of the missiles as well as the production of their launchers. To verify the Treaty, states parties were allowed on-site inspections at missile operating bases and missile support facilities.

Chemical weapons offer an alternative, non-nuclear example of a technology—in this case specific chemical compounds—that has been banned for use as a military technology. Following the use of mustard gas and other types of chemical warfare in WWI, the 1925 Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other

[23]Trachtenberg, "The Past and Future of Arms Control."

[24]These arguments are also explored in older theoretical work:Brodie, "Nuclear weapons: strategic or tactical?"; Schelling, "The strategy of conflict. Prospectus for a reorientation of game theory."

[25]Schelling, "Reciprocal measures for arms stabilization."

[26]Bull, "The Control of the Arms Race: Disarmament and Arms Control in the Missile Age.(Studies in International Security, II.)."

Gases, and of Bacteriological Methods of Warfare banned the use of chemical agents—gaseous or solid—from use in war. The Chemical Weapons Convention signed in 1991—and entered into force in 1997—further prohibited all states from producing or retaining chemical weapons with the Organization for the Prohibition of Chemical Weapons (OPCW) tasked with determining those chemical compounds that states are prohibited from stockpiling for military purposes.

In summary, arms control frameworks have a variety of goals and, as noted in the examples above have varying forms of membership, verification provisions, and flexibility mechanisms that are the subject of analysis in subsequent chapters. Below, I outline the use of the empirical record to shed light on how the type of arms control agreement influences patterns of state compliance.

4.4 Quantitative Analysis

Having outlined the various types of arms control agreements that states have developed to address advancements in military technologies, I move now to considering the question of how agreement type affects compliance outcomes—in this case using empirical data to investigate agreement compliance.

To test the hypotheses noted above, I carry out a series of regression analyses using the original Arms Control Design Dataset (ACDD).

4.4.1 The Arms Control Design Dataset (ACDD)

For the purposes of this chapter, I use a subset of strategic—that is, nuclear—arms control agreements that entered into force from Kreps's list of strategic arms control agreements as my selection criteria.[27] While this subset does not include agreements that deal with other regimes like the Chemical Weapons Convention or those agreements with secondary strategic consequences such as the Open Skies Treaty, it provides a useful tool for case selection with the intention of minimizing researcher-introduced bias. It also usefully allows for a comparison across a number of alternative dependent variables related to strategic weapons that are correlates of compliance. Among the 48 agreements considered by Kreps, I leave out those that never entered into force and those that are institutions rather than agreements. For example, while both the United States and USSR signed the SALT II Agreement designed to cap strategic forces and curtail development of new missiles in 1979, it was not ratified by the United States in response to the Soviet invasion of Afghanistan and subsequently expired in 1985 without entering into force. As a result, I do not include that agreement or those like it, including the Antisatellite Agreement of 1978, START II, or

[27]Kreps, "The institutional design of arms control agreements." This list also reflects those compiled by the Nuclear Threat Initiative, Federation of American Scientists, and Jozef Goldblat's work. Goldblat, *Arms control: a survey and appraisal of multilateral agreements*; Goldblat, *Arms Control: The New Guide to Negotiations and Agreements.*

START III.[28] The primary justification for this decision is that states cannot be reasonably expected to comply with arms control agreements that did not enter into force—even if they made the decision to sign them. Using this case selection criteria, the dataset used in this chapter includes thirty-six agreements comprising 1,187 agreement-years.[29]

In the section below, I introduce the variables coded within the Arms Control Design Dataset.

4.4.2 The Dependent Variable: Measuring Compliance

In the analysis, I use a dichotomous measure of compliance as the dependent variable that reflects allegations of breaches in treaty compliance and treaty violations.[30]

Unlike treaty obligations that are spelled out in agreements, coding compliance involves taking into account allegations of breaches from historical, journalistic, and government records. Where available, I use accounts in popular U.S. and international presses to corroborate noncompliance on an agreement-year and country-agreement-year basis.[31]

The ACDD includes a number of episodes of non-compliance across various types of arms control agreements. The 1999 Kargil crisis, for example, led to the abandonment of various confidence-building measures (CBMs) related to nuclear risk reduction included within the Lahore Declaration—itself an example of an arms control regime that falls within the "technology control" category of arms control agreements.[32] The ACDD also includes several incidences of non-compliance with commitments under test ban regimes. The most famous of these violations occurred during the Soviet Chagan test in 1965, which was designed to produce a "peaceful nuclear explosion" (PNE). The 140-kiloton blast, however, led to radioactive material being detected in Japan. The United States alleged that the the Soviets had violated its commitment concerning a ban on atmospheric or underground nuclear tests that caused "radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted."[33] The Soviets, in turn, alleged that the Pin Stripe underground test in 1966 and the Baneberry Shot test in 1970 at the Nevada Test Site violated the Treaty. Episodes of non-compliance associated with arms limitation agreements include the multilateral CFE Treaty that set limits on force deployments

[28]I also do not include the IAEA as an arms control agreement. While it does provide a role managing nuclear safeguards as an institution in support of several arms control agreements, it does not—in my estimation—constitute an arms control agreement in and of itself.

[29]All arms control agreements are weighed equally within the dataset.

[30]The coding criteria for measuring compliance is discussed at greater length in Chapter 3. The coding criteria for the dependent variable is also consistent across the chapters—and is included in each for the benefit of the reader and to go alongside the discussion of measurement concerning each independent variable of interest.

[31]The unit of analysis for this study is the former, agreement-year.

[32]S Paul Kapur, "India and Pakistan's Unstable Peace: Why Nuclear South Asia Is Not Like Cold War Europe," *International Security* 30, no. 2 (2005): 127–152.

[33]Article I of the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water.

Agreement Type	Score
No Control	0
Technology Control	1
Testing Bans	2
Arms Limitation	3
Prohibition	4

Table 4.1: The categorical agreement type variable.

in Europe. Russia announced its intention to suspend its implementation of the agreement in 2007 and Moscow decided to suspend the agreement in March of 2015. Episodes of non-compliance related to arms control designed to proscribe the development and use of specific military technologies include the ABM Treaty in the 1980s and the INF Treaty since 2008.

4.4.3 Independent Variables

The independent variables in this study reflect the categories of arms control type discussed above. This involves the creation of dichotomous variables reflecting those agreements that include aspects of `technology control` (such as the Nuclear Suppliers Group), `testing bans` (such as the TTBT), `arms limitation` (such as New START), and `prohibition` of arms development altogether (such as the ABM Treaty).

To the extent that these four types of agreements represent a continuum of arms control, I also create a categorical variable, `agreement type` in which each agreement is coded on a 5-point scale from 0-4.[34]

4.5 Results

In the section below, I examine the relationship between the type of arms control and patterns of compliance on an agreement-year basis. As Figure 4.1 makes clear, there are episodes of noncompliance across each type of arms control agreement that serve as the independent variable of interest for the study.

To begin, I test the effect of each type of arms control agreement on compliance using a probit regression model.[35] This model is most appropriate for dealing with dichotomous

[34] Agreements designed to control military technologies via export control or risk reduction receive a score of 1, test bans a score of 2, limitation agreements a score of 3, and prohibition agreements a score of 4. Agreements like the Hotline Agreement that do not seek to regulate a specific military technology receive a score of 0.

[35] A probit model uses a cumulative distribution function of the inverse standard normal distribution to define f (*)—rescaling the values of the dependent variable to fall between 0 and 1. Hence, whatever $\alpha + \beta x$ equals, it can be transformed by the function to yield a predicted probability.

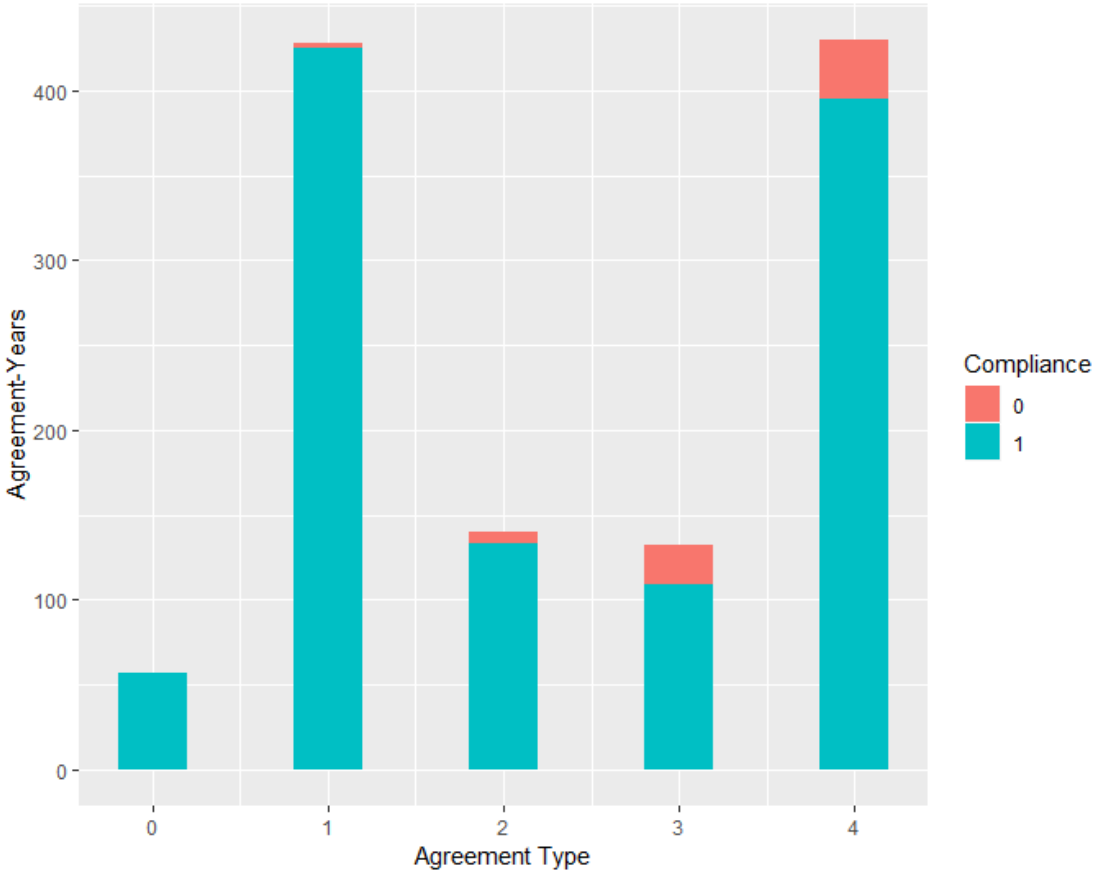

Figure 4.1: This figure provides a compliance count of agreement-years across different types of agreements. Red signifies non-compliance while green signifies compliance.

dependent variables in the context of social science research. The choice of a standard probit model also requires that the underlying data does not violate an assumption of homoskedasticity.[36]

The probit regression equation is:

$$\hat{Y} = f(\alpha + \beta x) \tag{4.1}$$

in which $\hat{Y}$ represents compliance and β represents the design characteristics examined in this chapter.

Table 4.1 reports the results of each type of arms control regime regressed against patterns of compliance.

Model 1 reports a negative and statistically significant correlation between agreements designed to prohibit military technologies and compliance. This finding is in line with the

[36]This assumption is interrogated in the sensitivity analysis, below, in which the analysis is re-run using robust clustered standard errors using a heteroskedastic probit model.

theory that arms control agreements that are "more difficult" represent a more significant compliance challenge. Mirroring this theory, Model 2 suggests that arms limitation agreements are negatively correlated with non-compliance of arms control regimes with statistical significance.

Model 3 finds no statistically significant relationship between testing regimes and non-compliance while Model 4 reports no statistically significant correlation between testing regimes and arms control regimes designed to control military technology for the purposes of export control or risk reduction and patterns of compliance.

Overall, these results suggest two inferences. First, there is variation in compliance with an arms control framework on the basis of the type of strategic problem that it is designed to address. Second, that prohibition agreements and, to a larger degree, arms limitation agreements are correlated with non-compliance with an arms control agreement on an agreement-year basis.

Table 4.2: Probit models reporting the effect of arms control agreement type on treaty compliance on an agreement-year basis

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Prohibition	-0.31 (0.11)***			
Limitation		-0.78 (0.15)***		
Testing Ban			0.07 (0.19)	
Technology Control				0.07 (0.12)
N	1187	1187	1187	1187
Log-likelihood	-257.0	-247.0	-260.4	-260.3
Constant	1.71 (0.08)	1.72 (0.07)	1.57 (0.06)	1.55 (0.08)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To interrogate these findings while engaging with a series of control variables that may also impact regime compliance, I construct a categorial variable that codes each agreement-year in the dataset on the basis of whether it corresponds to technology control (1), test ban (2), arms limitation (3), or prohibition (4). Models 5-8, reported in Table 4.2, assess the correlation between agreement type and compliance while considering a number of design- and non-design-related control variables.

Model 5, using this categorial `agreement type` variable suggests that a one-unit increase in agreement type decreases—with statistical significance—the predicted probability of compliance. The finding remains robust across a number of models, including a series of control variables.

In Models 6, I include other design variables theorized to affect compliance, including whether the agreement is multilateral, what type of verification regime is used to monitor the agreement, and whether the agreement is of finite or indefinite duration. This result

pertaining to agreement type holds across a number of models that include both design-related control variables. These findings will be revisited in the following chapters.

In Model 7, I include two additional control variables theorized to affect compliance. First, I include a dichotomous variable to account for whether the agreement-year (the unit of analysis for the study) occurs during the Cold War. Given that the Cold War conditions a majority of agreement-years within the dataset and Soviet-American patterns of adversarial cooperation were reflected in a number of agreements, this is an important driver of compliance to take into account. With that said, theories diverge with regard to the postulated effect of the Cold War on arms control regime compliance: On the one hand, the Cold War's stabilizing influence may contribute to higher levels of compliance; On the other, the mutual distrust intrinsic in the conflict may decrease both the likelihood of compliance within adversarial agreements and the reputation costs of noncompliance. Suggesting support for the former logic, the Cold War dummy in this analysis reports a positive correlation with compliance.

Second, I include a dichotomous variable that accounts for whether the arms control agreement builds upon a prior agreement. In theory, successor agreements may be more likely to yield compliance outcomes on the basis of prior successful negotiation and enforcement. For example, the arms limitations included in SORT built upon those outlined in START I and included in the START II and START III negotiations before being superseded by the entry into force of New START. Interestingly, this analyis suggests that successor status does not have a statistically significant effect on compliance outcomes.

In Model 8, I include all of the control variables and use this model for the translation of the probit model coefficients into predicted probabilities.

Table 4.3: Probit models for the effect of arms control agreement type using a categorical variable on treaty compliance on agreement-year basis

	(5) Model 5	(6) Model 6	(7) Model 7	(8) Model 8
Agreement Type	-0.29 (0.05)***	-0.46 (0.07)***	-0.52 (0.08)***	-0.47 (0.07)***
Multilateral		0.46 (0.17)***		0.43 (0.17)**
Stringency		0.17 (0.07)***		0.19 (0.07)***
Sunset		0.66 (0.27)**		0.73 (0.32)**
Successor			0.05 (0.23)	-0.20 (0.31)
Cold War			0.30 (0.16)*	0.31 (0.16)*
N	1187	1187	1187	1187
Log-likelihood	-242	-227.6	-240	-225.1
Constant	2.38 (0.17)	2.25 (0.19)	2.31 (0.18)	2.22 (0.20)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As discussed in Chapter 3, coefficients from probit models are more difficult to interpret than those from ordinary-least-squares regressions, as an increase in probability attributed

Table 4.4: This table shows the predicted probability of compliance for a given agreement-year on the basis of agreement type holding all control variables at their mean value.

Agreement Type	Predicted Probability of Compliance
No Control	99.8 %
Technology Control	99.3 %
Test Ban	97.6 %
Limitation	93.4 %
Prohibition	85.0 %

to a one-unit increase in a independent variable of interest is dependent on the values of the control variables. As a result, scholars often report the positive and negative values of the coefficients and their statistical significance rather than engaging with the values of the coefficients themselves. However, the results above can be used to calculate the predicted probability of the dependent variable of interest, in this case compliance.

Using Model 8, I calculate the predicted probability of compliance in any agreement-year using the coefficients noted in Table 4.2. For a given agreement-year, the predicted probability of compliance is given by the following equation:

$$\hat{Compliance} = F(2.22 - 0.47(\texttt{AgType}) + 0.43(\texttt{Multi}) + 0.19(\texttt{String}) + 0.73(\texttt{Sun}) - .20(\texttt{Succ}) + 0.31(\texttt{CW})) \tag{4.2}$$

where f is the cumulative distribution function of the inverse standard normal distribution and the values of each control variable are fixed.

This equation allows for the calculation of the predicted probability of compliance for each type of agreement on an agreement-year basis holding each of the covariates at their mean value.[37] The results are shown in Table 4.3. As predicted by both the dichotomous (Models 1-4) and categorical treatment (Models 5-8) of `agreement type` show that the predicted probability of compliance in any given agreement-year decreases as one moves up the agreement type continuum.[38]

For agreements that are non-binding and do not have any form of technology control, there is a 99.8 percent probability of compliance in any given agreement-year. For technology control agreements, this percentage falls slightly to 99.3 percent. For test bans, the chances of compliance in any agreement year are 97.6 percent. For arms limitation agreements, there is a 93.4 percent change of compliance in any given agreement-year. Finally, for agreements that seek to proscribe the development and deployment of specific military technologies, the chances of compliance with an agreement on a year-on-year basis falls to 85 percent in any

[37]This approach is most common in social science research, though one could also hold the covariates at their zero value to assess the relative absence of the covariates.

[38]These results are consistent with an analysis using alternative modeling approaches. In the Appendix to this chapter, I include a parallel analysis using logistic regression rather than the probit model described here.

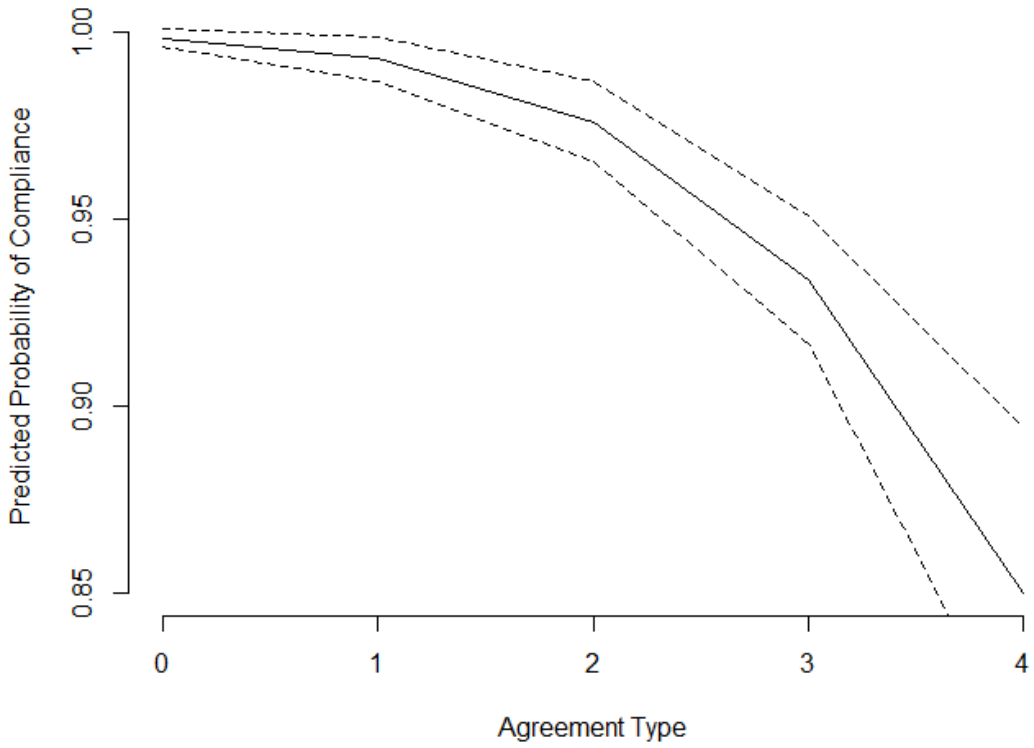

Figure 4.2: This figure shows the predicted probability of compliance on an agreement-year basis with 95 percent confidence intervals shown as dashed lines.

given agreement-year. This result reflects the broader findings noted in Table 4.1, suggesting that agreements that seek to "do more" have an increased chance of non-compliance.

These results can also be down in graph form. Using the categorical `agreement type` variable and holding the control variables from Model 8 at their mean values, Figure 4.2 plots the predicted probabilities of complying with each type of agreement on a percentage basis with 95 percent confidence intervals. At each point on the x-axis, agreement type, the y-value, the predicted probability of compliance, matches those values reported above.

4.6 Sensitivity Analysis

In the section below, I perform a series of econometric tests on the results of the analysis above to test the appropriateness of the modeling choices and specifications chosen to run the analysis. I begin by testing for the multicollinearity of variable effects on compliance

Table 4.5: This table shows the Variance Inflection Factor for the probit model including all four design variables and the Cold War and Successor control variables used in Model 8, above.

Variables	*Agreement Type*	*Stringency*	*Multilateral*	*Sunset*	*Cold War*	*Successor*
VIF	1.74	1.86	1.56	1.61	1.04	1.68

outcomes.

4.6.1 Multicollinearity

To do this, I use a variance inflation factor (VIF) to measure how easy it is to achieve the same model outcomes from a linear regression using the other predictors. The square root of the VIF tells you how much larger the standard error of the estimated coefficient is in respect to a case when that predictor is independent of the other predictors.

A general guideline is that a VIF larger than 5 indicates that the model has problems estimating the coefficient..[39] Table 4.5 below shows the VIF for Model 8 described in Table 4.3, above.

The results of this analysis suggest that multicollinearity, in which the explanatory variables are highly correlated, is not a concern for the analysis carried out above. I turn now to a consideration of the independence of the data points provided by ACDD's panel data.

4.6.2 Independence and Heteroskedasticity Probit Results

The existing methodological literature suggests that models using panel data may internalize substantial cross-sectional dependence within the error term. This may occur due to the presence of shocks common to the data points, unobserved phenomena that ultimately become part of the error term, or temporal dependence. To address concerns surrounding the independence of both the outcome variables and the regressors, I run a series of regression models with clustered standard errors that adjust for non-independence across agreements and across years. As I use standard probit models above, I use heteroskedastic probit models here.[40]

To do this, I assess whether the circumstances in which the variability of a variable is unequal across the range of values of a second variable that predicts it exist in the underlying data used in the standard probit models above. This test is particularly important given that heteroskedasticity in these models can represent a violation of standard probit (and logit) model specifications, which assume homoskedastic errors.

[39]Christopher Glen Thompson et al., "Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results," *Basic and Applied Social Psychology* 39, no. 2 (2017): 81–90.

[40]The appendix to this chapter also includes the standard logistic regression models for this chapter.

Below, I use the probit regression equation in Model 5 to test for heteroskedasticity when using the *Agreement Type* independent variable, shown below:

$$1 = F(2.38 - 0.29(\texttt{AgType}) \tag{4.3}$$

Recall, the standard errors within the standard probit model associated with the constant and the agreement type variable are, 0.17 and 0.05 respectively.

I subsequently calculate the Huber-White robust standard errors—also known as heteroskedasticity-consistent (HC) standard errors—reported in the Table 4.6.[41]

Table 4.6: This table shows the calculation of coefficients and robust standard errors using Model 5 that examines the effect of agreement type on the predicted probability of compliance

Variables	**Coefficient**	**Robust Standard Error**	***p* <0.05**
Constant	2.39	0.13	Yes
Agreement Type	-0.29	0.04	Yes

The minimal difference in standard errors suggests that the agreement type and compliance data are homoskedastic—and likely fulfill the criteria for using a standard probit model. However, the difference—if negligible—suggests that a subsequent analysis of the models using robust clustered standard errors in a heteroskedastic probit model may be warranted. I carry out and report this analysis, below. In the process, I check whether the findings related to the direction and statistical significance of the effects reported in Models 5-8 are consistent.[42]. I focus on Models 5-8 from the standard probit above as they serve as the quantitative basis for the finding that more prohibitive arms control agreements reduce the predicted probability of compliance on an agreement-year basis.

Table 4.7: Heteroskedastic probit models for the effect of arms control agreement type on treaty compliance on an agreement-year basis

[41]I use the *sandwich* R package to carry out this analysis.Achim Zeileis, "Object-oriented computation of sandwich estimators," *Journal of Statistical Software* 16, no. 9 (2006); Halbert White et al., "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity," *Econometrica* 48, no. 4 (1980): 817–838.

[42]These results are titled as Model 5HP to Model 8HP in which HP refers to "heteroskedastic probit" for ease of reading

	(5) Model 5HP	(6) Model 6HP	(7) Model 7HP	(8) Model 8HP
Agreement Type	-0.29 (0.04)***	-0.46 (0.06)***	-0.29 (0.04)***	-0.47 (0.06)***
Multilateral		0.46 (0.16)***		0.43 (0.16)***
Stringency		0.17 (0.07)***		0.19 (0.07)***
Sunset		0.66 (0.29)**		0.73 (0.42)***
Successor			0.05 (0.24)	-0.20 (0.35)
Cold War			0.30 (0.24)*	0.31 (0.17)*
N	1187	1187	1187	1187
Log-likelihood	-242	-227.6	-240	-225.1
Constant	2.39 (0.13)	2.25 (0.14)	2.31 (0.10)	2.22 (0.09)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Comparing the results using the standard probit and those of the heteroskedastic probit using robust clustered standard errors does not change the direction of the effect nor the statistical significance of the results reported above.

4.6.3 Time Dependence

I now turn to the question of whether the findings outlined above are driven by temporal dependence.

To address this, I use Carter and Signorino's cubic polynomial approximation method described in Chapter 3 to include t, t^2, and t^3 in several regression models described above. In these models t represents the time since the last "event."[43] In this analysis, the specific event at issue is a breach of an arms control agreement. Thus, t represents the time, in years, since the last episode of non-compliance on an agreement-year basis.

I report two models including t, t^2, and t^3. The first model presents the independent variable of interest while the second includes the independent variable of interest alongside the additional design characteristics and control variables.

Table 4.8: Cubic polynomial approximation probit models for the effect of arms control agreement type on treaty compliance on agreement-year basis

[43]Carter and Signorino, "Back to the future: Modeling time dependence in binary data."

	(5) Model 5	(5) Model 5CP	(8) Model 8	(8) Model 8CP
Agreement Type	-0.29 (0.05)***	-0.32 (0.08)***	-0.47 (0.07)***	-0.40 (0.10)***
Multilateral			0.43 (0.17)**	0.28 (0.24)
Stringency			0.19 (0.07)***	0.21 (0.09)**
Sunset			0.73 (0.32)**	0.65 (0.42)
Successor			-0.20 (0.31)	0.60 (0.45)
Cold War			0.31 (0.16)*	0.72 (0.22)***
t		1.08 (0.15)***		1.00 (0.14)***
t^2		-0.09 (0.02)***		-0.08 (0.01)***
t^3		0.002 (0.0004)***		0.002 (0.0004)***
N	1187	1187	1187	1187
Log-likelihood	-242	-121.9	-225.1	-109.1
Constant	2.38 (0.17)	-0.03 (0.32)	2.22 (0.20)	-0.59 (0.39)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As Table 4.8 shows, the cubic approximation probit models for Model 5 and Model 8 (denoted as Model 5CP and Model 8CP) above underline the main finding of the chapter concerning the effect of agreement type on compliance outcomes in the ACDD dataset. There are minimal differences in the regression coefficients and no change in the statistical significance of the result for the independent variable of interest, agreement type.

4.6.4 Selection Effects

As discussed in Chapter 3 and as Downs et al. and von Stein have noted, when an independent variable is itself a strategic choice on an outcome there are significant selection effects that must be taken into account when analyzing observational data.[44] In simplest terms, any outcome variables (in this case, compliance) must be measured against the predilection of a state taking the same action in the absence of the variable of interest (in this case an arms control agreement). As both the choice of a state to undertake an arms control agreement of a specific *design* and the decision to comply with an agreement on an agreement-year basis, the research in question .[45]

Thus, the findings presented in this chapter have the caveat, common among observational studies, that they provide a first cut at the causal relationship between institutional design characteristics and compliance outcomes on an agreement-year basis.

[44]Downs, Rocke, and Barsoom, "Is the good news about compliance good news about cooperation?"; Von Stein, "Do treaties constrain or screen? Selection bias and treaty compliance."

[45]In the chapters that follow, the *Agreement Type* variable itself is used as a regressor to account for the "difficulty" of an agreement conditioning the effects of the independent variables concerning verification, termination clauses, and membership, respectively.

4.7 Conclusion

The theoretical results of this analysis using the ACDD data are two-fold. First, compliance outcomes vary based on the scope of the agreement. Second, the analysis above suggests that agreements that attempt to curtail the number of weapons or prohibit states from deploying military technologies represent the most likely types of arms control agreement that states parties are likely to violate. In the chapters to follow I examine how the design characteristics of these agreements may also contribute to compliance and/or non-compliance. Reflecting on the hypotheses discussed above, this section considers how the results of this analysis interact with existing theoretical research.

I begin by considering hypotheses from normative theory. Normative scholars suggest that logics of appropriateness are embedded within arms control regimes—particularly those that ban the development and use of certain military technologies including nuclear, chemical, and biological weapons that a number of scholars suggest are "unusable" regardless of the context. As noted above, this logic is used to explain the non-use of biological, chemical, and nuclear weapons in the existing literature.[46] However, the results above suggest that more restrictive arms control regimes designed to limit, ban, or otherwise constrain the development and deployment of nuclear weapons are negatively correlated with compliance outcomes—the opposite finding that normative scholars might expect:

With that said, the development and deployment of nuclear weapons is not the same thing as using them in anger. As a result, the jury remains out regarding the contribution of logics of appropriateness related to the *use* of proscribed military technologies. What this analysis does suggest, however, is that arms control agreements designed to prohibit the development and deployment of nuclear weapons have the highest predicted probability of noncompliance.

I turn now to a consideration of realist scholarship. Realist scholars, particularly those who see little value in international institutions, are likely to find mixed support for their theoretical propositions embedded within the findings of this chapter. On the one hand, it appears that states largely abide by their agreements. Indeed, even among those agreements that fundamentally limit state behavior by limiting their arsenal and prohibiting the development of certain types of weapons, an analysis of the empirical record suggests that states party to an agreement will comply 85 percent of the time in any given agreement-year. On the other, those agreements in which states are most likely to renege on their commitments are those that realists might expect—those that affect the material security of the state by limiting or prohibiting the development of specific military technologies.

Among institutionalist scholars, who might expect fairly static measures of compliance across varied types of agreements as each is crafted to address different arms control challenges, I find limited support given the top-line finding that compliance outcomes appear to vary based on the scope of the agreement. An alternative proposition might suggest

[46] Tannenwald, "The nuclear taboo: The United States and the normative basis of nuclear non-use"; Price, "A genealogy of the chemical weapons taboo"; Tannenwald, "Stigmatizing the bomb: Origins of the nuclear taboo."

that compliance outcomes are baked into the strategic dilemma that an arms control regime is designed to address and that while design characteristics might soften the likelihood of noncompliance, it remains a "hard" problem and as a result the relative performance of an agreement is likely to vary based on agreement type.

The analysis above has two clear implications. First, there is variation in patterns of compliance on the basis of the arms control challenge that an agreement is seeking to address—given the selected sample of agreement-years addressing nuclear weapons. Second, to the extent that there is a continuum of arms control types, those agreements that are most restrictive in terms of managing state behavior represent the most significant compliance challenges. So, what can be learned from this analysis? In the section below, I consider the policy relevant aspects of the analysis above, note a series of avenues for further research, and outline the chapter to follow.

Considering the contemporary challenges to international security posed by emerging technologies, from hypersonic missiles to cyber weapons, this analysis suggests that it is essential for policy-makers to first assess the types of policy solutions being proposed in the bargaining phase surrounding regime creation to address these technologies. They must also consider their downstream consequences for compliance—and particularly the degree to which it restricts state behavior. For example, it may be the case that softer, norm-based commitments focused on risk reduction and export control represent a more propitious path forward concerning efforts to regulate emerging technologies and engender state compliance compared to regulatory efforts to prohibit their development and deployment altogether. Alternatively, policy-makers might consider including measures to address the downstream risks of non-compliance in agreements that limit or prohibit certain types of state behavior. These might include, for example, verification measures that detect noncompliance early or flexibility mechanisms that allow states parties to revisit the strategic problem that a particular arms control agreement is designed to address.

In terms of the contemporary efforts to create a ban on nuclear weapons via the TPNW, or "Ban Treaty," and calls to address a slew of new military technologies such as autonomous weapons that a number of civil society groups and governments have called to ban, the empirical record of non-compliance with agreements that proscribe the development and deployment of specific types of military technology are worthy of further consideration: In simple terms, be careful what you wish for. While prohibition agreements may read well in principle, more work is needed to unpack the causes of non-compliance and why these types of agreements are particularly susceptible to violations.

With that goal in mind, in the chapter to follow I investigate how various types of verification regime "work" in support of arms control to parse debates about the appropriate institutional designs and technical tools to be used in pursuit of compliance. Specifically, I examine how various verification regimes—from information exchanges to inspection regimes—affect compliance. In the process, I also point to a number of empirical examples that vary in terms of their verification regime type including the IAEA (NPT), Special Verification Commission (INF), Nuclear Suppliers Group, and Bilateral Consultative Commission (START) as well as discussing the consequences of the analysis for future arms control agreements beyond

nuclear weapons.

Appendix

The choice to use probit or logit models is generally considered to be one of personal preference when dealing with dichotomous outcome variables. As a reminder, OLS regressions are inappropriate as the errors from a linear probability model with dichotomous outcome variables violate homoskedasticity and normality of errors assumptions, resulting in invalid standard errors. As mentioned in Chapter 3, there is increasingly disagreement about whether these drawbacks inherent within OLS methods necessitate the use of probit or logit estimators.

Below, I carry out an identical analysis to those carried out using probit regression methods using logistic regression. The number associated with each model remains the same with those using a logistic regression denoting an L. For example, Model 1 above can be compared to Model 1L, below.

Table 4.9: Logit models reporting the effect of arms control agreement type on treaty compliance on an agreement-year basis

	(1) Model 1L	(2) Model 2L	(3) Model 3L	(4) Model 4L
Prohibition	-0.66 (0.25)***			
Limitation		-1.56 (0.28)***		
Testing Ban			0.16 (0.41)	
Technology Control				0.16 (0.26)
N	1187	1187	1187	1187
Log-likelihood	-257.0	-247.0	-260.4	-260.3
Constant	3.09 (0.18)	3.11 (0.15)	2.78 (0.13)	2.74 (0.16)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

While the coefficient estimates change, their sign and statistically significance remain the same using either both the probit and logit modeling approaches.

Table 4.10: Logit models for the effect of arms control agreement type using a categorical variable on treaty compliance on agreement-year basis

	(5) Model 5L	(6) Model 6L	(7) Model 7L	(8) Model 8L
Agreement Type	-0.59 (0.11)***	-0.94 (0.14)***	-0.56 (0.12)***	-0.95 (0.14)***
Multilateral		1.02 (0.34)***		0.99 (0.34)***
Stringency		0.36 (0.13)***		0.36 (0.13)***
Sunset		1.51 (0.63)**		1.14 (0.76)**
Successor			0.23 (0.34)	-0.47 (0.69)
Cold War			0.74 (0.34)**	0.63 (0.35)*
N	1187	1187	1187	1187
Log-likelihood	-242	-227.6	-240	-225.1
Constant	4.49 (0.39)	4.18 (0.42)	4.31 (0.41)	2.22 (0.20)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As is the case above, the results remain the same in terms of both the sign associated with the coefficient and the statistical significance of the result—suggesting that the results are not sensitive to the choice of modeling approach.

Chapter 5

Is More Better? The Effects of Verification Regime Type on Compliance

Abstract

Much has been made of how to craft verification mechanisms that "work" in support of arms control—leading to debates about the appropriate institutional designs and technical tools to be used in pursuit of compliance. However, the causes and consequences of the inclusion of verification mechanisms in existing and historical arms control agreements have not been subject to systematic empirical analysis. In this chapter, I use the original "Arms Control Design Dataset" (ACDD) that tracks design characteristics of arms control regimes on an agreement-year basis to examine the effect of various verification regimes—from information exchanges to challenge inspections—on compliance. In the process, I also point to a number of empirical examples that vary in terms of their verification regime type, including the IAEA (NPT), Special Verification Commission (INF), Nuclear Suppliers Group, and Bilateral Consultative Commission (START) as well as discussing the consequences of the analysis for future arms control agreements beyond nuclear weapons.

5.1 Introduction

Doveryai, no proveryai.

During meetings with Ronald Reagan, Suzanne Massie taught the U.S. President a famous Russian proverb that loosely translates as, "Trust, but verify." The phrase was repeated by the President on many occasions—including during the signing of the now-troublesome INF Treaty in 1987—as well as other diplomats in reference to recent efforts to govern and regulate the use of various technologies in warfare. For example, U.S. Secretary of State John Kerry, responding to Syria's use of chemical weapons, noted that "Trust but verify...

is in need of an update. And we have committed here to a standard that says, 'Verify and verify'... If we can join together and make this framework a success and eliminate Syrias chemical weapons, we would not only save lives, but we would reduce the threat to the region, and reinforce an international standard, an international norm." Verification has, indeed, become something of panacea for policy-makers.

In general, measures specified in international agreements designed to monitor and verify compliance with a particular regime have been theorized to contribute to compliance.[1] As Reagan argued in 1987, the INF Treaty should include "extensive verification procedures that would enable both sides to monitor compliance with the treaty."

In the years since, the inclination to include monitoring and verification mechanisms in arms control agreements has represented something of a conventional wisdom. Whether verification mechanisms perform as advertised, however, has not been analyzed empirically.

In this chapter, I use the Arms Control Design Dataset (ACDD) to examine the varying efforts used to monitor and verify compliance within arms control agreements to answer two related research questions:

- Do verification regimes contribute to compliance?
- What are the relative effects of various types of verification regimes upon compliance?

Of the more than one hundred frameworks designed to regulate, constrain, or ban military technology, there is considerable variation in their design—particularly in terms of their scope, membership, verification mechanisms, and flexibility. The consequences of this variation, however, have yet to be systematically observed and examined—by academics or arms control negotiators.[2]

In the process, I adjudicate between two arguments: First, that verification regimes contribute to "trust" and therefore represent a necessary condition for compliance. Second, that verification regimes may offer a politically necessary but insufficient condition for compliance. The quantitative analysis below suggests that the latter is more likely to represent reality.

In the following, I examine the existing literature pertaining to verification in the context of arms control. Then, I introduce the original Arms Control Design Dataset and describe how monitoring and verification are measured. I then present a series of models that suggest that the conventional wisdom concerning the effects of various types of verification requires

[1] Kosta Tsipis, David W Hafemeister, and Penny Janeway, *Arms control verification: The technologies that make it possible* (Pergamon Books Inc., Elmsford, NY, 1986).

[2] The absence of a robust discussion pertaining to the causes and consequences of arms control agreements have contributed to a reliance upon the heuristic inclinations of arms control negotiators concerning which types of monitoring and verification measures are most appropriate. In a series of interviews with previous U.S. and British negotiators of SALT I, START I, CFE, SORT, and NPT extension in 1995, the personal and past experience of the negotiators in the room was consistently heralded as a driver of the success in terms of reaching an agreement and of driving the inclusion of various design characteristics in the agreements themselves.

further examination. Finally, I consider the case of the Intermediate-Range Nuclear Forces (INF) Treaty, which offers useful within-case variation with regard to the effect of verification on compliance.

5.2 Verification and Arms Control

At the outset, it is worth noting that—like arms control more generally—I treat verification as a process rather than as an outcome. This process can be considered in one of two ways—a technical challenge and a political process. There is a tendency (usually among engineers and physicists) to conceptualize verification as a technical challenge.[3] For example, remote sensing, hyper- and multi-spectral satellite imaging, radar imaging, infrared surveillance, seismological monitoring, information barriers, and zero-knowledge processes for verification each contribute to the technical aspects of verification.[4] While there is a steady proliferation of technologies and processes that contribute to enhanced monitoring and verification procedures, it is worth noting that among policy-makers there is an understanding that 100 percent verification is not possible.[5] As a consequence, designers of arms control agreements have used the standard of "effective verification" in which state parties to an agreement have adequate time to respond to a breach of an agreement. Negotiators for the New START agreement in Geneva, for example, decided to include 18 on-site inspections per year in an attempt to meet this standard.[6] And while the technical aspects of arms control are no doubt important, I argue, for the purposes of this paper, that monitoring and verification remains a political process—often contingent upon states parties agreeing to monitoring and inspection procedures.

In the section below, I outline the variety of institutional mechanisms created to address monitoring and compliance issues.

5.2.1 Types of Verification Regime

The types of verification regime examined in this section are designed to be collectively exhaustive, but it is important to note that they are rarely mutually exclusive as a large number of agreements employ a variety of institutional mechanisms to monitor and verify

[3]David Hafemeister, Kosta Tsipis, and JJ ROMM, "The verification of compliance with arms-control agreements," *Scientific American* 252, no. 3 (1985): 29–35.

[4]Tsipis, Hafemeister, and Janeway, *Arms control verification: The technologies that make it possible*; Moritz Kutt, Malte Gottsche, and Alex Glaser, "Disarmament Hacking 2.0: Toward a Trusted, Open-Hardware Computing Platform for Nuclear Warhead Verification," in *57th Annual Meeting of the Institute for Nuclear Materials Management, Atlanta, GA* (2016); Sebastien Philippe et al., "A physical zero-knowledge object-comparison system for nuclear warhead verification," *Nature Communications* 7 (2016): 12890.

[5]This was repeatedly discussed in various meetings with arms control negotiators involved in START I, INF, CFE, and New START negotiations. See also: Amy F Woolf, "Monitoring and Verification in Arms Control," *Congressional Research Service* 41201 (2011).

[6]Interview with Dr. Mona Dreicer. March 29, 2019.

agreements. The INF Treaty, for example, called for the exchange of data at the outset of the treaty framework to determine each state's stockpiles of Soviet SS-12s, SS-23s, SS-20s, SS-4s, and SS-5s and U.S. Gryphon GLCMs and Pershing-IIs. Baseline on-site inspections followed to determine the veracity of these declarations in the three-year period of elimination with a varying number of on-site inspections allowed each year and "portal monitoring" at production facilities for a period of 13 years until the sunset of the verification regime in 2001. Below, I define the three categories of cooperative monitoring and verification regime analyzed in this chapter: information exchanges, on-site inspection regimes, and challenge inspections. Loosely, we might consider these types of monitoring and verification tools on a continuum of "stringency" or "intrusiveness," though I analyze each separately before constructing and analyzing them as a categorical variable, `stringency`. There is, of course, a final category of agreements that do not specify or include a monitoring and verification regime.

A number of regimes also call for the use of unilateral "national technical means"—a euphemism for a government's use of intelligence assets to verify compliance with an agreement while others include mechanisms that note a commitment among states parties to limit efforts to obfuscate the intelligence picture provided by these technical means.

Article V of SALT I first mentions, but does not define, the term:

> 1. For the purpose of providing assurance of compliance with the provisions of this Interim Agreement, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.
>
> 2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
>
> 3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Interim Agreement. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.[7]

National technical means of verification involve the use of a number of intelligence, surveillance, and reconnaissance platforms such as satellites to obtain multi- and hyper-spectral imagery and seismology stations designed to detect underground nuclear tests and, more recently, missile tests. In practice, most states use intelligence assets to assess both ally and adversary behavior. While future work may consider unilateral information collection, this analysis begins by considering information exchanges before moving onto on-site inspections and challenge inspections that are often used to verify this information.

[7]SALT I, Article V.

5.2.2 Information Exchange

In contrast to the unilateral activities undertaken within the "national technical means" regime, information exchange offers a bilateral or multilateral activity in which states share information related to a military technology of interest.

Under INFCIRC-153 of the Nuclear Nonproliferation Treaty (NPT), for example, non-nuclear weapon states have an annual reporting requirement to divulge the balance of nuclear material in the country and its various uses—whether in medical imaging, nuclear energy programs, or basic research. This regime is designed to both deter and detect the diversion of nuclear weapon for proscribed activities (in normal cases, weapon development).

Information exchanges are also common at the outset of agreements as governments divulge existing stockpiles of weapons, the state of their weapon development programs, and, in some cases, their locations. In some agreements, this information is used as a baseline for a subsequent inspection regime.

In existing treatments of arms control, those agreements that include only a clause related to national technical means of verification and that are limited to information exchanges are most often classified as "low monitoring" regimes rather than "high monitoring" regimes that involve putting inspectors on the ground in country.[8]

5.2.3 On-Site Inspection Regimes

As mentioned above, the bilateral and multilateral information sharing regimes are subject to corroboration via on-site inspections. Perhaps unsurprisingly, there are a large variety of types of inspection regimes with rules concerning where the inspections take place, who is permitted to perform the inspection, how long the inspection will last, how many inspections can be performed (usually measured on an inspection per year basis), and what type of inspections are appropriate. These types of regime are the subject of lengthy negotiations and varying on the basis of appropriateness given the technology being regulated.

The INF Treaty, used as an example throughout this section, includes a specific number of inspections to be carried out each year that varied as the agreement aged. Article XI, par. 5 notes that:

> Each Party shall have the right to conduct inspections pursuant to this paragraph for 13 years after entry into force of this Treaty. Each Party shall have the right to conduct 20 such inspections per calendar year during the first three years after entry into force of this Treaty, 15 such inspections per calendar year during the subsequent five years, and ten such inspections per calendar year during the last five years. (Article X, par. 5)

9

[8] Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

[9] INF Treaty, Article X, par. 5.

During the first three years of the Treaty, also described as the "elimination phase," the inspections were designed to compare the data received during the exchange of information between the USSR and the United States at the culmination of the negotiations and to track progress toward the elimination of intermediate-range nuclear forces (specifically, a ballistic missile with a range of 3,000 to 5,500 kilometers).

Interestingly, while a number of arms control agreements make clear that there should be an inspection mechanism associated with a treaty, policy-makers, engineers, and scientists were often left to craft the specific rules and procedures associated with an inspection regime after the Treaty was completed. Often, these would take the form of a memorandum of understanding or a protocol to the treaty. The Protocol Regarding Inspections Relating to The INF Treaty serves as just one example. The Protocol itself outlined the process for carrying out the on-site inspections associated with the regime, including the minutiae associated with inspections such as the pre-inspection requirements (Article III), the notifications of an inspection that both serve as a notice to the inspected state that inspectors are arriving, and a number of requirements related to leaving the inspected location in an unchanged state (Article IV). This process is designed to deter and prevent states from moving weapon stockpiles prior to inspection. There are also general rules concerning responsibilities undertaken by the inspectors themselves:

> Inspectors shall not disclose information received during inspections except with the express permission of the inspecting Party. They shall remain bound by this obligation after their assignment as inspectors has ended. (Article VI, par. 2)

The Annex to the Protocol also outlines the privileges and immunities provided to inspectors while they are carrying out inspections.

While the majority of on-site inspection regimes are discontinuous—that is, inspectors enter and subsequently leave the inspected state—the INF and START I Treaty both provided for continuous "portal monitoring" to address specific aspects of the Treaty. Article VI of the INF Treaty notes that neither party shall "produce" intermediate-range or shorter-range missile, missile stage, or launcher. To verify this prohibition, both the United States and the Soviets had the right to station up to 30 on-site inspectors on the perimeter and on the transportation portals of a former INF final missile assembly or production plant. The United States created a portal monitoring system to monitor both rail and road traffic into and out of the Votkinsk Machine Building Factory in the Ural Mountains while the Soviets decided to observe a former rocket motor production plant in Magna, Utah.

In START I, the portal monitoring system provided for an accurate count of the number of ballistic missiles leaving Soviet facilities and a more accurate estimate of the total number of mobile ICBMs in their respective force. The portal monitoring regime is described by Amy Woolf of the Congressional Research Service as:

> perimeter/portal continuous monitoring systems (PPCMS) consisted of fences surrounding the entire perimeter of the facility and one restricted portal through which all vehicles large enough to carry items limited by the treaty (such as the

> first stage of a mobile ICBM) had to pass. The portal contained scales and other measuring devices that the countries could use to determine whether the vehicle carried an item limited by the treaty.[10]

In cases of both discontinuous and continuous monitoring, on-site inspections are routinized by design. The challenge for policy-makers, however, becomes what activities occur at the sites outside of inspection windows or at sites that are undeclared in information exchanges by parties to a Treaty.

5.2.4 Challenge Inspection Regimes

The answer to the last question is the creation of a mechanism that broadens the scope of inspection beyond the routinized regime noted above. In part to address the concerns that states remain able to abrogate their commitments vis à vis the development and deployment of proscribed military technologies, policy-makers turned to challenge inspections—particularly in multilateral contexts. A challenge inspection occurs when a state party believes that another party to an arms control agreement is undertaking a prohibited activity. This state party then challenges the other party to allow inspectors to investigate the alleged breach. Unlike the on-site inspection regime noted above, challenge inspections can occur *anywhere* and *anytime* with substantially fewer limits on inspector access and disclosure.

Negotiations surrounding one of the early nuclear-adjacent arms control frameworks, the Seabed Treaty (the Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof), illustrates the difficulty of negotiating and creating an institutional framework. The negotiations, starting in 1969 and culminating with the Treaty entering into force in 1972, involved the dissemination of two drafts—one by the USSR and another by the United States. These two drafts differed on the issue of verification with the Soviets—using the recently drafted Outer Space Treaty as a guide—proposing that all installations and structures on the seabed be open to inspections. According to the U.S. Department of State, the United States "felt that to attempt to inspect for the emplacement of all kinds of weapons would make the problems connected with verification virtually insuperable."[11] To address this dissensus, Article III, Par. 2 of the Treaty would go on to establish one of the early "challenge" inspection processes related to arms control:[12]

> If after such observation reasonable doubts remain concerning the fulfillment of the obligations assumed under the Treaty, the State Party having such doubts and the State Party that is responsible for the activities giving rise to the doubts

[10] Woolf, "Monitoring and Verification in Arms Control."

[11] Narrative and Treaty text from the Bureau of International Security and Nonproliferation. "Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof" Available at:'https://www.state.gov/t/isn/5187.htm

[12] In the ACDD, the first challenge inspection process was included in the Antarctic Treaty which entered into force in 1959.

> shall consult with a view to removing the doubts. If the doubts persist, the State Party having such doubts shall notify the other States Parties, and the Parties concerned shall cooperate on such further procedures for verification as may be agreed, including appropriate inspection of objects, structures, installations or other facilities that reasonably may be expected to be of a kind described in Article I. The Parties in the region of the activities, including any coastal State, and any other Party so requesting, shall be entitled to participate in such consultation and cooperation. After completion of the further procedures for verification, an appropriate report shall be circulated to other Parties by the Party that initiated such procedures. (Article III, par. 2)

More recently, the Conventional Armed Forces in Europe Treaty (CFE), used a hybrid system of what the Treaty describes as "passive" inspections of declared sites and limited number of "challenge" inspections included as a proportion of the number of overall inspections undertaken each year—until Russia announced its suspension of the agreement in 2015. Challenge inspections have also been included in treaties creating regional nuclear-weapon-free zones including the Treaty of Tlatelolco in Latin America and Treaty of Bangkok in Southeast Asia.

In comparison to the on-site inspection regime noted above, challenge inspections vary in a three important ways. First, inspection sites can be either declared or undeclared via information exchanges. Second, inspected parties generally have less time to prepare for the inspection. And third, challenge inspections are generally intrusive as activities with longer time horizons such as portal monitoring are no longer viable. As a consequence, challenge inspection regimes are most often considered at the "high" end of the monitoring and verification continuum.

5.2.5 Verification and Enforcement Institutions

As well as varying in terms of verification design, there have also been a variety of monitoring and verification institutions created to address the implementation and verification of arms control. These fall into two categories that broadly reflect the membership of an agreement.

First, there are tailored institutions designed to address compliance issues related a specific treaty. Tailored institutions that address implementation and compliance issues have their origins in early efforts to control nuclear weapons. SALT I's Standing Consultative Commission (SCC) offers the first example of this type of institution that continues to be used today. The INF Treaty created the Special Verification Commission (SVC) charged with meeting at the request of a state party to discuss compliance issues. The SVC also played a key role in designing the on-site inspection rules and regulations that would become part of the Protocol to the Treaty outlined above. Like the INF, the New START Treaty includes the tailored Bilateral Consultative Commission (BCC) to address the practical implementation of the treaty commitments of states parties. These institutions tend to be bilateral or

multilateral and have no permanent staff associated with them. These Commissions involve government officials from the governments of states parties and are often *ad hoc*.

Rather than the *ad hoc* institutions involving representatives of states parties noted above, intergovernmental organizations with professional and permanent staffs represent an alternative type of verification organization. The modal example in terms of nuclear weapons is the International Atomic Energy Agency (IAEA), which has a role in supporting the implementation of the Nuclear Nonproliferation Treaty (NPT) via its safeguards agreements with non-nuclear weapons states (NNWS). The IAEA has also been tasked with overseeing safeguards associated with various treaties related to nuclear-weapon-free zones (NWFZs) such as Central Asia Nuclear-Weapon-Free Zone (Treaty of Semei) as well as efforts to account for all nuclear material used for energy and research purposes in effort to prevent their diversion to weapons programs—e.g. Convention on the Physical Protection of Nuclear Material. The UN's 1540 Committee has also been given responsibility for the implementation of UNSC 1540 in which states are obliged to "refrain from supporting by any means non-State actors from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their means of delivery."[13] Treaty-specific organizations such as the Organization for the Prohibition of Chemical Weapons (OPCW)—the implementing body for the Chemical Weapons Convention—and the Comprehensive Test Ban Treaty Organization (CTBTO)—the implementing body for the Comprehensive Test Ban Treaty that has yet to enter into force—also serve as examples of this type of organization. These types of institutions tend to have professional staffs, a Secretariat, a budget supported by states parties, and limited integration into the broader UN system.

As with the design of arms control agreements themselves, the relative effects of each type of organization responsible for implementation and verification concerns in arms control remains under-studied.

5.3 Verification in Theory

As U.S. President Reagan's remarks make clear, there is an expectation that the form of an arms control agreement follows function. That is, agreements that have stringent verification mechanisms are expected to engender greater compliance. Indeed, when "assessing" arms control agreements, the ability to come to an agreement with high levels of monitoring and verification for the agreement are viewed as a success: "verification has become the most important standard against which arms control agreements—both past and prospective—are measured."[14] This presents a challenge given what has been described as a verification paradox: "the paradox of nuclear arms control is that monitoring strategic weapons is easiest

[13]UN Security Council Resolution 1540 (2004) updated in UNSC 1673 (2006), UNSC 1810 (2008), UNSC 1977 (2011).

[14]William C Potter, "Verification and arms control," 1985,

when it's needed least, and hardest when it's needed most."[15]

In the section to follow, I outline the functionalist, evolutionary, and norm-setting aspects verification from a theoretical perspective. These theories subsequently link to a series of hypotheses concerning the probabilistic effect of verification design on patterns of compliance and non-compliance.

Scholars of institutional design have long pointed to the variety of institutional forms in the design of international agreements—whether related to their "bindingness," formalization, membership, and degree of legalization.[16] Much of this work explains the variation in institutional design in terms of two limiting factors. First, the agreement between parties to the agreement. Second, the role that an institution is designed to play—whether in terms of trade, environmental protection, or collective security. In simple terms, "form follows function."

In considering arms control, specifically, "the common conception is that treaties are not complied with because they are unenforceable, and that the cure for this condition is treaties 'with teeth.'"[17] This contributed to the hypothesis that increasing the "verifiability" of an agreement would contribute to compliance.[18] In practice, this stance has been reflected in critiques of existing verification institutions such as the Standing Consultative Committee—the bilateral body created to address implementation and compliance issues related to strategic arms limitation.[19]

Similar to the theory that form follows function, an evolutionary perspective of arms control suggests that lessons learned from past agreements—and their performance—contribute to decisions to make verification and enforcement mechanisms increasingly robust.[20] This also, to some extent, reflects the theoretical work regarding institutional learning—though in this case, the "learners" are states.[21]

Beyond the functionalist and evolutionary explanations noted above, it is also worth pointing out the normative importance of arms control agreements—as well as their sub-

[15]Nancy W Gallagher, "The politics of verification: Why 'how much?' is not enough," *Contemporary Security Policy* 18, no. 2 (1997): 138–170.

[16]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Miles Kahler, "Multilateralism with small and large numbers," *International Organization* 46, no. 3 (1992): 681–708; Kal Raustiala, "Form and substance in international agreements," *American Journal of International Law* 99, no. 3 (2005): 581–614; Vabulas and Snidal, "Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements"; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[17]Chayes and Chayes, "Compliance without enforcement: state behavior under regulatory treaties."

[18]Stephen M Meyer, "Verification and risk in arms control," *International Security* 8, no. 4 (1984): 111–126.

[19]Sidney N Graybeal and Michael Krepon, "Making better use of the standing consultative commission," *International Security* 10, no. 2 (1985): 183–199.

[20]Burns, *The evolution of arms control: from antiquity to the nuclear age.*

[21]Ovodenko and Keohane, "Institutional diffusion in international environmental affairs"; James G March and Johan P Olsen, "The institutional dynamics of international political orders," *International Organization* 52, no. 4 (1998): 943–969.

sidiary verification regimes—which has little to do with arms control outcomes and more to do with pointing to an ethical or moral imperative. Often, the normative aspects of verification (and arms control more generally) are ignored in favor of the "performative" aspects of arms control. Given new efforts to create normative frameworks without verification mechanisms to address frontier military technologies including weapons deployed in space and cyber attacks on critical infrastructure, this offers an important avenue of future research. As Guthe points out:

> Some agreements may not lend themselves to verification and will inevitably be violated, but might still be valuable for setting international norms. The Biological Weapons Convention is a good example. For most agreements, however, the Reagan Administration maxim of "trust but verify" should be amended, in light of the case studies covered here, to "verify but still don't trust." The party entering the agreement should carefully develop the monitoring, verification and prospective enforcement measures required to deter and detect any cheating, no matter how unlikely it might appear at the time.[22]

As noted in the theory chapter of this dissertation, there is also a null hypothesis suggesting that there is no effect of institutional design on outcomes and that alternative variables contribute to non-compliance. Meyer, for example, points to the "difficulties [that] eventually arise because it is assumed incorrectly that the political context that exists at the time the agreements are signed will persist through their lifetime."[23] In other words, the political environment conditions both the process of verification and the outcome of the arms control agreement.

5.4 Hypotheses

Reflecting the theories noted above, the hypotheses below account for the effects of verification regime type on compliance. In the section below, I detail how verification regimes that vary in terms of intrusiveness affect compliance.

5.4.1 The Conventional Wisdom

In line with both the functional and evolutionary perspectives concerning the effect of verification, H_1 reflects the conventional wisdom that "more" verification is better:

- H_1: If a verification regime is more stringent, then it will have a positive effect on compliance.

[22]Kurt Guthe et al., "Securing Compliance with Arms Control Agreements," 2016,
[23]Meyer, "Verification and risk in arms control."

5.4.2 The Null Hypothesis

The next hypothesis accounts for the null, in which the design of a verification regime has no effect on compliance—and in which other variables may, in fact, be driving compliance outcomes. The null also accounts for non-functional drivers of verification regime inclusion such as domestic political considerations.

- H_0: The design of a verification regime has no effect on compliance.

5.4.3 Surveillance Bias and Selection

Finally, I account for the H_1's opposite:

- H_2: If a verification regime is more stringent, then it will have a negative effect on compliance.

There are two theoretical drivers that may result in H_2: a *selection effect*, and a *surveillance bias effect*. The first, a selection effect, relates to the intrinsic difficulty (or ease) associated with compliance with an arms control agreement *prior* to agreement design that may influence both the design of an agreement and the outcome of the agreement: those agreements that states were going to find most difficult to comply with regardless of the design of the arms control agreement may include the most stringent verification regimes.

The second, surveillance bias—also described as detection bias—is an under-explored phenomenon in international relations scholarship that has its roots in medicine.[24] There, the premise of surveillance bias is that the construction of mechanisms to detect a particular outcome will lead to an increased detection of this outcome. By way of analogy, a hammer (representing a verification regime)will constantly search for and find a nail (noncompliance). Thus, those agreements that have a more stringent verification mechanism—a larger hammer—may have a higher probability of detecting non-compliance.[25]

The type of institutional body used for determining how to implement and verify an arms control agreement may also increase or decrease the likelihood of the severity of surveillance bias. For example, those agreements that have formal institutions with professional staffs may be more likely to fall victim to surveillance bias as the detection of non-compliant activity may reflect upon the utility of institution. Alternatively, those institutions that are more closely tied to the practice of state competition may lead to *realpolitik* considerations in making (or not making) allegations of noncompliance.

[24]Paolo Vineis and Anthony J McMichael, "Bias and confounding in molecular epidemiological studies: special considerations.," *Carcinogenesis* 19, no. 12 (1998): 2063–2067.

[25]I am thankful to Prof. Kathryn Sikkink for her advice concerning the integration of surveillance bias as a cause of noncompliance into this chapter.

5.5 Research Design

To address the question of how verification mechanisms impact compliance, I use the ACDD dataset that compiles nuclear-related arms control agreements that have been negotiated and entered into force between 1945 and 2019 and codes each based on its design characteristics. The dataset, composed of time-series panel data, is designed for longitudinal analysis.

For the purposes of this chapter, I use a subset of nuclear arms control agreements that entered into force from Kreps' list of arms control agreements used to examine the drivers of ratification and non-ratification as the case selection criteria.[26] While this subset does not include agreements that deal with other strategic threats such as the Chemical Weapons Convention or those agreements with secondary strategic consequences such as the Open Skies Treaty, it provides a useful tool for case selection with the intention of minimizing researcher-introduced bias. It also usefully allows for a comparison across a number of alternative dependent variables related to nuclear weapons that are correlates of compliance. Among the 48 agreements considered by Kreps, I leave out those that never entered into force and those that are institutions rather than agreements in this analysis. The primary justification for this decision is that states cannot be reasonably expected to comply with agreements that never entered into force—even if they made the decision to sign them. Using this case selection criteria, the dataset used in this chapter includes 40 agreements comprising 1,187 agreement-years.[27]

In this analysis, I consider two sets of independent variables related to the discussion above: verification design characteristics and verification organization.

5.5.1 Verification Variables

The first set of independent variables consider the types of verification regimes included in the arms control agreement measured in two ways. The first provides a column for each of the following verification regime types: information exchange, on-site inspection regime, and challenge inspection regime (described in greater detail above). The second involves the construction of a categorical variable, `stringency`, constructed by summing each of the dichotomous measures above:

$$Stringency = \sum(+\texttt{Inf Exchange}+\texttt{On-Site Inspection}+\texttt{Challenge Inspection}) \quad (5.1)$$

The equation allows for an analysis of those agreements that place higher verification requirements upon states parties against those that do not.

[26] Kreps, "The institutional design of arms control agreements" This list also reflects those compiled by the Nuclear Threat Initiative, Federation of American Scientists, and Jozef Goldblat's work.Goldblat, *Arms control: a survey and appraisal of multilateral agreements*; Goldblat, *Arms Control: The New Guide to Negotiations and Agreements*

[27] All arms control agreements are weighed equally within the dataset.

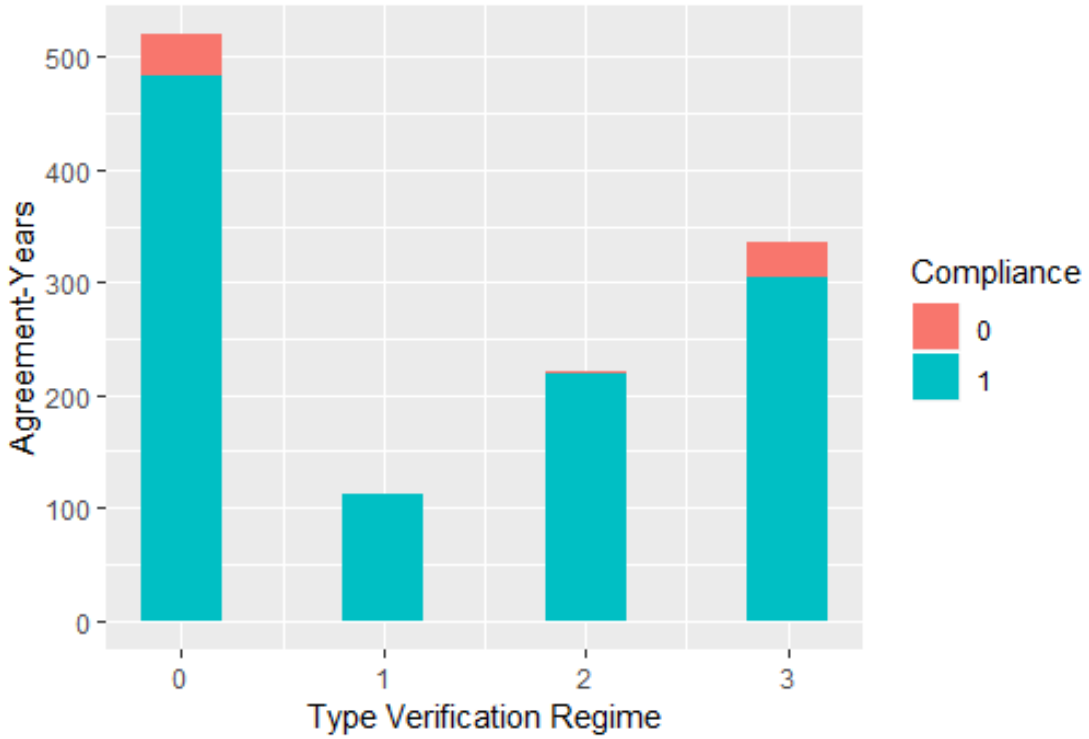

Figure 5.1: This figure shows the variation in "strength" of the verification regime with compliance agreement-years shown in green and non-compliance agreement-years shown in red.

5.5.2 Verification Organization Variables

The second set of independent variables I consider is the type of organization used to implement and verify the agreement. As noted above, I categorize these institutions into the following: tailored institutions that are created on an *ad hoc* basis and standing intergovernmental organizations that are given a verification and monitoring role.

5.5.3 Dependent Variable: Compliance

In the analysis, I use a dichotomous measure of compliance as the dependent variable.[28]

As described in the previous chapter, treaty obligations that are spelled out in agreements while coding compliance involves taking into account allegations of breaches from historical, journalistic, and government records. Where available, I use accounts in popular U.S.

[28]The coding criteria for measuring compliance is discussed at greater length in Chapter 3. The coding criteria for the dependent variable is also consistent across the chapters—and is included in each for the benefit of the reader and to go alongside the discussion of measurement concerning each independent variable of interest.

and international presses to corroborate noncompliance on an agreement-year and country-agreement-year basis. For example, the construction of the Yeniseysk-15 phased array radar at Krasnoyarsk in 1980 led to allegations by the United States in 1983 that the USSR was in violation of its commitments to the ABM Treaty. More recently, Russian deployment of the 9M729 on the Iskander launcher in 2008 represented a breach of the INF Treaty. Russia, in response, argued that U.S. missile defense forces were also in breach of the Treaty. Compliance, for the purposes of this study, relates to states abiding by the letter of their agreements.

Using these variables, I test the effect of each type of verification regime on patterns of compliance on an agreement-year basis. To do this, I use a probit regression equation appropriate for analysis when considering a dichotomous dependent variable:[29]

$$\hat{Y} = f(\alpha + \beta x) \tag{5.2}$$

I use the same model to assess the effect of varying verification regimes on compliance outcomes in any given agreement-year.

5.6 Results

In the section below, I outline the results of several probit regression models that measure the effect of verification mechanisms on compliance dichotomously and by using a categorical variable, `stringency`. I subsequently turn to an examination of the effects of the types of organization carrying out the verification.

5.6.1 Verification Regime Type and Compliance

Models 1-4 consider the effect of verification regime (information exchange, on-site inspection, and challenge inspection) on the predicted probability of compliance on an agreement-year basis. The results of this analysis are reported in Table 5.1 and in graph form in Figure 5.2.

Table 5.1: Probit model results for the effect of verification regime type on compliance

[29] A probit model uses a cumulative distribution function of the inverse standard normal distribution to define f (*)—rescaling the values of the dependent variable to fall between 0 and 1. Hence, whatever $\alpha + \beta x$ equals, it can be transformed by the function to yield a predicted probability of compliance on an agreement-year basis. Alternative model specifications for are included in the Appendix.

	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
No Verification	-0.18 (0.12)			
Information Exchange		0.10 (0.12)		
On-Site Inspection			-0.01 (0.12)	
Challenge Inspection				-0.29 (0.12)**
N	1187	1187	1187	1187
Log-likelihood	-259.3	-260.1	-260.5	-257.7
Constant	1.66 (0.08)	1.53 (0.08)	1.58 (0.08)	1.68 (0.08)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Model 1, the absence of a verification regime has a negative but statistically insignificant effect on the predicted probability of compliance. Model 2, testing the effects of information exchange, reports a positive but statistically insignificant result. Model 3, examining the effect of on-site verification regimes reports a negative and statistically insignificant result. In each of the three models, I cannot reject the null that each of the design characteristics do not impact the predicted probability of compliance. In Model 4 assessing the effect of challenge inspection regimes, the model suggests that there is a negative and statistically significant effect on the predicted probability of compliance in a given agreement-year.

This analysis provides two propositions. First, recalling the result of Model 4, arms control outcomes vary based on verification design. Second, challenge inspection regimes, posited as the most stringent and subsequently most likely to induce compliance, may have unintended consequences.

Given the patterns of non-compliance in the dataset shown in Figure 5.1, this result is perhaps unsurprising—and suggests that to the extent that verification impacts compliance, there may be a "goldilocks" level of verification.

To examine the impact of verification in the aggregate, I turn now to an examination of the categorical `stringency` variable.

Table 5.2: Probit models for the effect of stringency of verification mechanism on treaty compliance on agreement-year basis

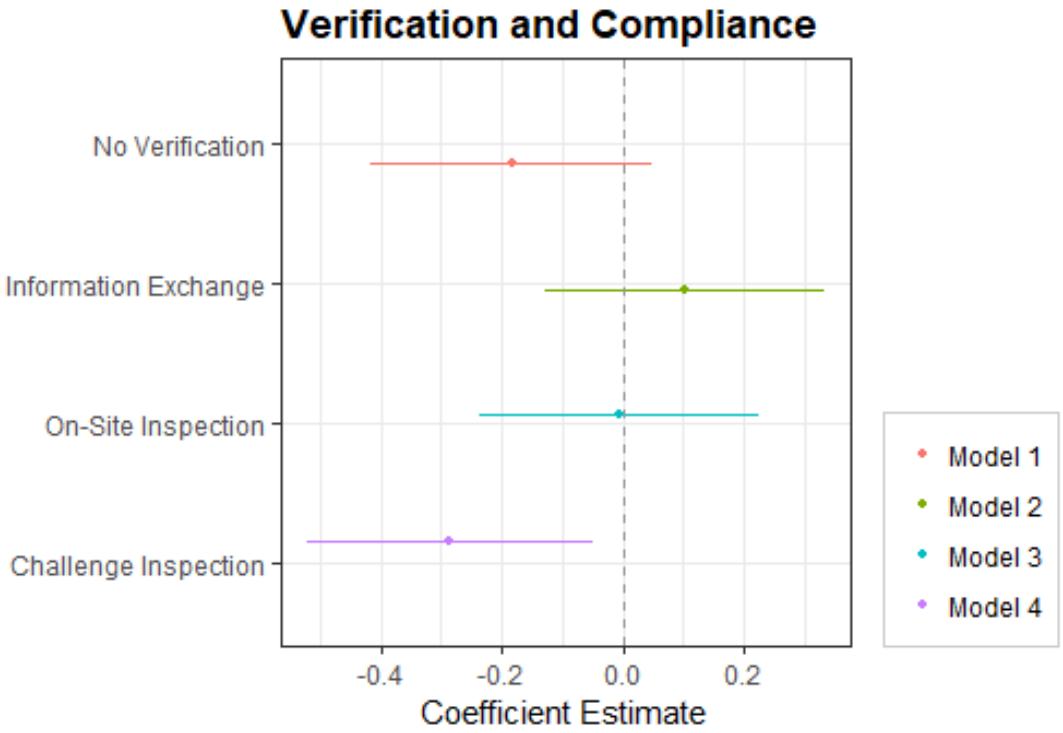

Figure 5.2: This figure graphs the regression results from Models 1, 2, 3, and 4.

	(5) Model 5	(6) Model 6	(7) Model 7	(8) Model 8
Stringency	-0.02 (0.05)	0.17 (0.07)**	-0.01 (0.05)	0.19 (0.07) ***
Multilateral		0.46 (0.17)***		0.43 (0.17)**
Sunset		0.67 (0.27)**		0.73 (0.32)**
Agreement Type		-0.46 (0.07)***		-0.47 (0.07)***
Cold War			0.34 (0.15)**	0.31 (0.16)*
Successor			0.32 (0.23)	-0.20 (0.31)
N	1187	1187	1187	1187
Log-likelihood	-260.3	-227.6	-257.1	-206.5
Constant	1.61 (0.09)	2.25 (0.19)	1.49 (0.09)	2.22 (0.20)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Model 5, evaluating the effect of verification regime on the predicted probability of compliance, finds a negative and statistically insignificant relationship between the two. In Models 6 and 8, which account for a series of institutional design characteristics theorized to impact compliance, a one-unit increase in the stringency of an agreement is correlated with an increase and statistically significant effect on compliance. Model 7, accounting for a Cold War control variable and a control variable to account for whether an agreement represents

Table 5.3: This table shows the predicted probability of compliance on the basis of the stringency of the verification regime measured in Model 8 holding all control variables at their mean value.

Verification Type	**Predicted Probability of Compliance**
No Verification	93.9 %
Information Exchange	95.9 %
On-Site Inspection	97.3 %
Challenge Inspection	98.2 %

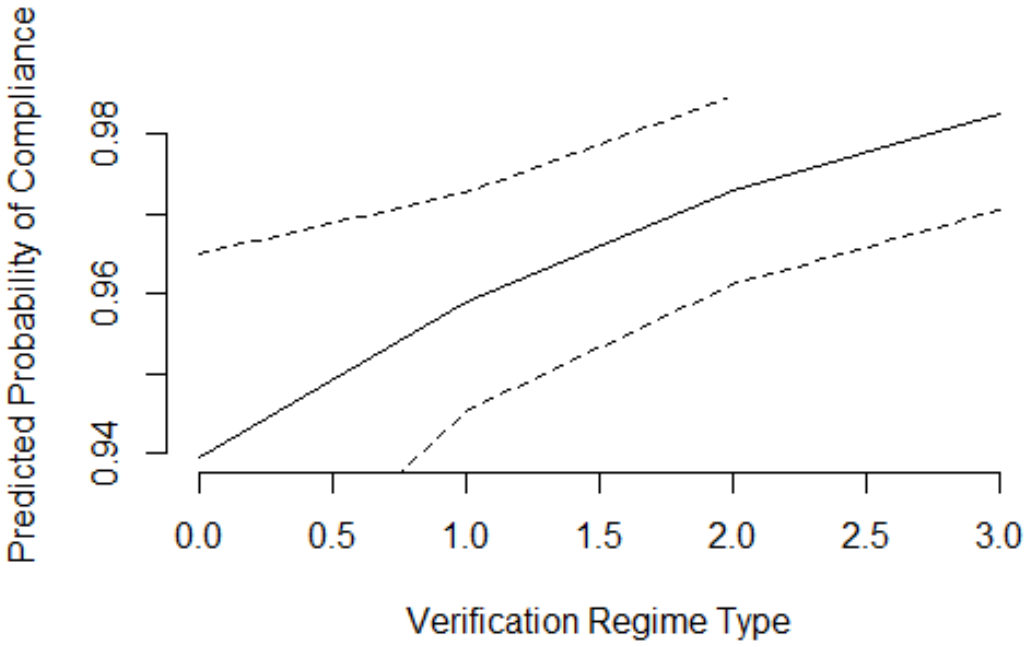

Figure 5.3: This figure shows the predicted probability of compliance on an agreement-year basis with 95 percent confidence intervals shown as dashed lines.

a follow-on, or successor, agreement, finds the same negative and statistically insignificant finding as Model 5. Incidentally, the results in Model 7 mirror those in Chapter 4 concerning Cold War effects and the relative lack of successor agreement effects.

Using the coefficients reported in Model 8—and holding each of the control variables at their means—Table 5.3 shows the predicted probabilities of compliance for each type of verification regime. These results are also plotted with their 95 percent confidence intervals in Figure 5.3

In aggregate, this analysis suggests that the inclusion of verification regimes may have a positive effect on the predicted probability of compliance. It is also suggests, however, that this distribution may be n-shaped. That is, arms control regimes with no verification regime are at substantial risk of non-compliance while the most stringent regimes that include challenge inspection regimes also share this risk. With regard to the conventional wisdom that more verification is better, the results of this analysis suggest that this is only the case up to a point. The analysis also suggests that there may be a need to engage with theory concerning the negative relationship between the most stringent verification regimes and patterns of compliance—whether on the basis of selection or detection bias discussed above.[30]

5.6.2 Verification Organization Analysis

Having discussed how the type of verification regime affects compliance, I turn now to assess how different types of organizations charged with addressing monitoring, verification, and compliance concerns might affect compliance outcomes using the same probit regression method. As noted above, I compare organizations that are tailored to address a specific agreement (usually on an ad hoc basis), such as the INF's Special Verification Commission, with those agreements that task intergovernmental organizations, such as the IAEA, OPCW, or CTBTO, with implementing the monitoring and verification of an arms control agreement—usually with professional staffs.

Table 5.4: Probit models for the effect of verification organization type on compliance

	(9)	(10)
	Model 9	Model 10
Tailored	-0.42 (0.12)***	
Intergovernmental		-0.20 (0.13)
N	1187	1187
Log-likelihood	-254.7	-259.3
Constant	1.72 (0.08)	1.63 (0.07)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Using Models 9 and 10, I calculate the predicted probability of compliance for those agreement-years with each type of organization overseeing monitoring, verification, and compliance. For ad hoc, treaty-specific agreements, there is a 90.3 percent chance of compliance on an agreement-year basis. For agreements involving intergovernmental organizations, the predicted probability of compliance for a given agreement-year is 92.4 percent—suggesting a relative performance benefit for those agreements that involve international institutions.

[30]These results are consistent with an analysis using alternative modeling approaches. In the Appendix to this chapter, I include a parallel analysis using logistic regression rather than the probit model described here.

Table 5.5: This table shows the Variance Inflection Factor for the probit model including all four design variables and the Cold War and Successor control variables used in Model 8, above.

Variables	*Stringency*	*Agreement Type*	*Multilateral*	*Sunset*	*Cold War*	*Successor*
VIF	1.86	1.74	1.56	1.61	1.04	1.68

5.7 Sensitivity Analysis

In the section below, I carry out a series of econometric tests to assess the modeling specifications and the results reported in the quantitative analysis above.

5.7.1 Multicollinearity

First, I test the multicollinearity of the standard probit model. To do this, I use a variance inflation factor (VIF) to measure how easy it is to achieve the same model outcomes from a linear regression using the other predictors. The square root of the VIF tells you how much larger the standard error of the estimated coefficient is in respect to a case when that predictor is independent of the other predictors.

A general guideline is that a VIF value larger than 5 or 10 indicates that the model has problems estimating the coefficient..[31] Table 5.5 below shows the VIF for Model 8 that includes the independent variable of interest and each of the control variables used in the study.[32]

The results of this analysis suggest that multicollinearity, in which the explanatory variables are highly correlated, is likely not a concern for the analysis above.

5.7.2 Independence and Heteroskedasticity Probit Results

The existing methodological literature suggests that models using panel data may internalize substantial cross-sectional dependence in the errors. This may occur due to the presence of shocks common to the data points, unobserved phenomena that ultimately become part of the error term, or past events influencing subsequent events. To address concerns surrounding the independence of both the outcome variables and the regressors, I run a series of regression models with clustered standard errors that adjust for non-independence across agreements and across years.

To do this, I assess whether circumstances in which the variance of a variable is unequal across the range of values of a second variable that predicts it exist in the underlying data

[31] Thompson et al., "Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results."

[32] These results are similar to those in Chapter 4.

used in the probit models above. This test is particularly important given that heteroskedasticity in these models can represent a major violation of the non-linear model specifications, which assume homoskedastic errors.

Below, I use a heteroskedastic probit model using Huber-White robust standard errors—also known as heteroskedasticity-consistent (HC) standard errors—reported in Models 5HC-8HC

Table 5.6: Heteroskedastic probit models for the effect of stringency of verification mechanism on treaty compliance on agreement-year basis

	(5) Model 5HP	(6) Model 6HP	(7) Model 7HP	(8) Model 8HP
Stringency	-0.02 (0.05)	0.18 (0.07)**	-0.01 (0.05)	0.20 (0.07) ***
Multilateral		0.44 (0.17)***		0.42 (0.16)**
Sunset		0.83 (0.34)**		0.86 (0.52)*
Agreement Type		-0.48 (0.06)***		-0.47 (0.07)***
Cold War			0.34 (0.15)**	0.31 (0.17)*
Successor			0.45 (0.26)	-0.11 (0.43)
N	1187	1187	1187	1187
Log-likelihood	-242	-222.7	-253.7	-220.6
Constant	1.61 (0.09)	2.29 (0.14)	1.48 (0.09)	2.23 (0.10)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Consistent with the analysis carried out in Chapter 4, there are no appreciable differences in results using the heteroskedastic probit model with robust clustered standard errors.[33]

5.7.3 Time Dependence

I now turn to the question of whether the findings outlined above are driven by temporal dependence.

To address this, I use Carter and Signorino's cubic polynomial approximation method described in Chapter 3 to include t, t^2, and t^3 in several regression models described above. In these models t represents the time since the last "event."[34] In this analysis, the specific event at issue is a breach of an arms control agreement. Thus, t represents the time, in years, since the last episode of non-compliance on an agreement-year basis.

I report two models including t, t^2, and t^3. The first model presents the independent variable of interest while the second includes the independent variable of interest alongside the additional design characteristics and control variables.

[33]I use the *sandwich* R package to carry out this analysis.Zeileis, "Object-oriented computation of sandwich estimators"; White et al., "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity."

[34]Carter and Signorino, "Back to the future: Modeling time dependence in binary data."

Table 5.7: Cubic polynomial approximation probit models for the effect stringency on treaty compliance on agreement-year basis

	(5) Model 5	(5) Model 5CP	(8) Model 8	(8) Model 8CP
Stringency	-0.02 (0.05)	0.02 (0.06)	0.19 (0.07)***	0.21 (0.09)**
Agreement Type			-0.47 (0.07)***	-0.40 (0.10)***
Multilateral			0.43 (0.17)**	0.28 (0.24)
Sunset			0.73 (0.32)**	0.65 (0.42)
Successor			-0.20 (0.31)	0.60 (0.45)
Cold War			0.31 (0.16)*	0.72 (0.22)***
t		1.12 (0.15)***		1.00 (0.14)***
t^2		-0.09 (0.02)***		-0.08 (0.01)***
t^3		0.002 (0.0004)***		0.002 (0.0004)***
N	1187	1187	1187	1187
Log-likelihood	-260.3	-130.9	-225.1	-109.1
Constant	1.61 (0.09)	-1.04 (0.24)	2.22 (0.20)	-0.59 (0.39)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The models including t, t^2, and t^3 are in line with the analysis and findings reported above with the coefficient from Model 8 (0.19) and Model 8CP (0.21) broadly similar in terms of both value and statistical significance.

5.7.4 Selection Effects

As discussed in Chapter 3 and as Downs et al. and von Stein have noted, when an independent variable is itself a strategic choice on an outcome there are significant selection effects that must be taken into account when analyzing observational data.[35] In simplest terms, any outcome variables (in this case, compliance) must be measured against the predilection of a state taking the same action in the absence of the variable of interest (in this case an arms control agreement). As both the choice of a state to undertake an arms control agreement of a specific *design* and the decision to comply with an agreement on an agreement-year basis, the research in question .

In this agreement-year-based analysis of the ACDD, the analysis does not consider that the "enforce-ability" of the agreement as well as the underlying probability of compliance for states parties varies and that this variation affects both the choice of institutional design designed into the arms control regime as well as the compliance outcome. The analysis above, does not, for example, preclude that states might choose the highest level of verification for the hardest cases and so its unsurprising that they do get failure.

[35]Downs, Rocke, and Barsoom, "Is the good news about compliance good news about cooperation?"; Von Stein, "Do treaties constrain or screen? Selection bias and treaty compliance."

Thus, the findings presented in this chapter have the caveat, common among observational studies, that they provide a first cut at the causal relationship between institutional design characteristics and compliance outcomes on an agreement-year basis.

5.8 Case Analysis: The INF Treaty

To engage with the empirical findings noted above, I examine the INF Treaty. Given recent events surrounding Russia's breach of the Treaty and the declaration by both the United States and Russia that they will leave the Treaty in late 2019, focusing on this Treaty offers a policy-relevant case for analysis. For the purposes of qualitative comparison, it offers useful within-case variation as its verification regime sunsetted in 2001.

Numerous experts have explored the geopolitical and strategic ramifications of US withdrawal from the Treaty. Podvig, for example, has argued that Russia's violation fails to "reach the level that would justify destruction of a key disarmament agreement, most likely bringing irreparable damage to the larger arms control architecture." US officials, on the other hand, have argued that triggering the 60-day notification period for withdrawal (which US Secretary of State Mike Pompeo announced on 4 December 2018) is warranted by Russia's alleged noncompliance. Pompeo's ultimatum states that Russia must return to "full and verifiable compliance" with the INF Treaty or the United States would provide its official notification of withdrawal from the Treaty, in accordance with Article XV, par. 2. As outlined in the Treaty, withdrawal enters into effect six months after this notification, which must include "a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests."[36]

While much has been made in the policy literature of the political failures that have contributed to this crisis, what has been largely ignored in the debate is the part played by weaknesses in the structural design of the INF Treaty itself. This case study examines the structural design of the INF Treaty and argues that its flaws—specifically the sunset of its verification regime in 2001—has contributed to the difficulty in addressing allegations of noncompliance within the current arms control framework. This design flaw also conditions the prospects for the INF Treaty regime moving forward amid heated debates concerning the appropriateness of withdrawal, amendment, or replacement of the Treaty and the respective consequences for the future of nuclear arms control.

5.8.1 Origins of the INF Treaty

The INF Treaty was designed to address "intermediate nuclear forces"—ground-launched ballistic missiles (GLBMs) and ground-launched cruise missiles (GLCMs) with ranges of between 1,000 and 5,500 kilometers—and their destabilizing consequences in the European theatre. From the informal, bilateral negotiations in 1980 to discuss limiting intermediate-range nuclear forces, the verification regime associated with any agreement weapons repre-

[36]INF Treaty, Article XV, par. 2.

sented a central concern. Six years of formal negotiations took place concerning the timeline and benchmarks related to the removal of intermediate systems, their deployment beyond Europe, and the inclusion and design of the verification regime, as well as the creation of the Special Verification Commission (SVC) mentioned above "to meet at the other partys request" as a forum to resolve implementation and compliance issues.[37] The Commission was also charged with interpreting the Protocol on Inspection and outlining the characteristics and use of inspection equipment.

Throughout its first two decades, the INF Treaty represented a significant—and, arguably, the signature—achievement of arms control in that it prohibited the development and deployment of an entire class of weapons that were adjudged to be destabilizing. Following the Washington Summit in 1987, approximately 2,600 missiles were dismantled during the three-year elimination period. The INF Treaty was also part of a broader suite of European and transatlantic arms control agreements, including the 1992 Treaty on Conventional Armed Forces in Europe (CFE) and 1991 Strategic Arms Reduction Treaty (START I). As Kimball and Reif note, the INF Treaty also "marked the first time the superpowers had agreed to reduce their nuclear arsenals, eliminate an entire category of nuclear weapons, and utilize extensive on-site inspections for verification."[38] The Treaty was also multilateralized following the end of the Cold War with the inclusion of Belarus, Kazakhstan, and Ukraine.[39]

5.8.2 Verification Design

Perhaps because of its roots in the Cold War, the inspection procedures outlined in the Treaty to verify compliance were both numerous and robust.

The protocols on "inspection" and "elimination" outlined several on-site inspection processes. These included baseline inspections to compare the site against data provided during an initial comprehensive data exchange, as well as six-monthly information exchanges facilitated by the Nuclear Risk Reduction Centres, closeout inspections of INF facilities as they are taken offline, a limited number of short-notice inspections of declared and formerly declared INF facilities, and elimination inspections to confirm that the procedures outlined in the Agreed Statement on Inspection (1988) were being followed. The inspection regime included a number of requirements vis à vis notification procedures as well as annual quotas concerning the number of inspections allowed. In the first three years of the Treaty, each Party was allowed 20 inspections in each year. In the following five years, this was reduced to 15 inspections before a further reduction to 10 inspections per year in the final five years of the inspection regime ending in 2001.

The Treaty also allowed the United States to undertake continuous portal monitoring—an intrusive verification measure for monitoring missile assembly plants—of any Soviet facility manufacturing a GLBM with a rocket stage "outwardly similar" to a stage of a GLBM

[37]INF Treaty, Article XIII.

[38]Arms Control Association et al., *The intermediate-range nuclear forces (INF) treaty at a glance*, 2017.

[39]The effect of bilateral, minilateral, and multilateral arms control frameworks are the topic of Chapter 7 to follow.

limited by the Treaty. The Soviet Union received a similar right to monitor the U.S. facility that formerly built the Pershing rocket motor.

5.8.3 The INF Regime in Practice

By at least 2011, however, the United States believed that Russia was an INF compliance concern. According to members of the U.S. Administration, these concerns were raised in several meetings with Russian diplomats throughout 2013, and in July 2014 the United States officially accused Russia of violating the Treaty. In the 2014 edition of its Compliance Report, the U.S. State Department alleged that Russia began the covert development of a mobile, intermediate-range, ground-launched cruise missile designated as 9M729 (SSC-8) in 2008, and that this weapon system was not in compliance with Russia's INF obligations not to "possess, produce, or flight-test" missiles prohibited by the Treaty. The basis for this conclusion remains unclear but Washington has at various times noted that the missile system has been flight-tested as a ground-launched cruise missile to ranges prohibited by the Treaty. From the US perspective, these relatively low-cost and survivable capabilities provide Russia with more options to strike allied military targets and populations without consuming Russia's inventory of strategic offensive weapons and theatre-strike resources, such as sea-launched cruise missiles. Following repeated denials from Moscow that such a weapon existed, the United States in 2016 called the first meeting of the SVC for 13 years to address Russian compliance issues—and the 30th such meeting of the Commission since the inception of the Treaty. Another meeting of the SVC followed in December 2017.

During both SVC meetings, Moscow denied that the weapon system was in breach of the Treaty and little progress was made to address the alleged INF violations. Moscow has subsequently accused the United States of violating the Treaty through the deployment of missile defence systems to Eastern Europe. Specifically, Russia argues that the Mk-41 launch system for air defence missiles can also be used to fire cruise missiles. In December 2017, Moscow also claimed that Japanese acquisition of U.S.-built Aegis Ashore systems also constituted a breach of the Treaty. Since then, the allegations and counter-allegations from both sides have done little to alleviate concerns over the viability of the Treaty.

Over the past two years, U.S. policy-makers have put the responsibility for INF issues squarely in Moscow's corner. Andrea Thompson, U.S. Under Secretary of State for Arms Control and International Security, remarked in a recent speech "either you rid the system, rid the launcher or change the system where it doesn't exceed the range, in a verifiable manner."[40] Similarly, the Director of National Intelligence, Daniel Coats stated, "Russia has shown no sign that it is willing to acknowledge its violation, let alone return to full and verifiable compliance."[41]

[40]Press briefing on December 6, 2018.

[41]Press briefing on November 27, 2018. Full text is available at the DNI website: https://www.dni.gov/

5.8.4 Design Matters

One of the intriguing, if unsurprising, aspects of remarks from U.S. policy-makers is the focus on verification as part of a remedy for Russian noncompliance with the INF Treaty. As mentioned above, the INF Treaty's inspection regime had three stages. The first lasted three years and supported the elimination of intermediate-range forces. The second and third stages each lasted five years, with a gradual drawdown in the number of on-site inspections allowed by each side. After 13 years, in 2001, the inspection regime for verifying INF commitments ceased (Article XI, par 5, par. 6). Following the sunset of the verification regime, portal monitoring at a missile factory in Votkinsk, Russia, continued on the basis of treaty commitments in New START, but the United States and Russia no longer had the right to conduct on-site inspections at the INF facilities identified via the information exchanges outlined in the Treaty text.

Of course, sunset clauses are not unusual in arms control and nonproliferation agreements.[42] The Non-Proliferation Treaty (NPT), START frameworks, and test ban treaties have all included sunset clauses that provide an endpoint to member states' respective commitments. So, why include a sunset clause inside the verification regime of an agreement? In theory, sunset mechanisms are meant to make negotiations more likely to succeed by limiting the future obligations of states parties. Unlike many agreements, however, the INF Treaty does not have a sunset clause for the treaty as a whole. Instead, the INF Treaty lasts in perpetuity (or until such time as one party withdraws) but without a verification mechanism 13 years after its inception.[43]

To some extent, this design feature can be explained by the focus on INF facilities that existed in the 1980s with no contingencies made for the potential of parties to the Treaty building new facilities and/or capabilities—at least not without parties leaving the Treaty entirely "if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests" (Article XV, par. 2).

The reality of the INF verification regime's sunset clause presented three discrete challenges to policy-makers in addressing post-sunset violations and noncompliance.[44]

First, attributing noncompliance since 2003 has been complicated by the lack of an inspection regime. In the case of the SSC-8 missile system first deployed in 2008, attributing noncompliance to Russia and communicating the allegation of a breach to allies and Moscow took four years. While both Russia and the United States have adequate national technical means to analyze one another's capabilities, uncertainty remains regarding weapon capabilities and effects—particularly systems that are limited on the basis of range that might otherwise look similar to smaller-range and larger-range systems. It is also worth considering the "selection effects" associated with the decision to develop and deploy an INF (or INF-adjacent system). A number of policy-makers noted that Moscow potentially

[42]Sunset mechanisms—or termination clauses—are the subject of Chapter 6 to follow.

[43]INF Treaty, Art. XV, par. 1.

[44]This analysis draws on a series of interviews with former policy-makers in a series of not-for-attribution discussions from 2017 to 2019.

viewed the violation of the INF Treaty as low-cost given the lack of attention paid to it by Washington—exemplified by the fact that there had been no meeting of the SVC for a decade. If a verification regime had existed during the development phase of a new INF system, it may have influenced the decision to develop it in the first place, given the reputation costs associated with a Treaty breach. Indeed, a number of former policy-makers noted that the Russian decision to build and deploy the SSC-8 reflected bureaucratic politics as well as long-standing concerns surrounding the viability of the INF framework amid the continued development of intermediate-range nuclear and non-nuclear forces in China, India, Pakistan, and others.[45] Without the verification regime, attribution of the breach only occurred during flight-testing and deployment of the system.

Second, there is limited information available concerning weapon system capabilities to create new standards for compliance. For agreements that limit rather than ban weapons systems, parties to an agreement need a basis to measure weapon characteristics in order to attribute compliance or breaches. Without an inspection architecture and fewer weapon systems are available to inspect, discussions of technical specifications related to missile and payload capabilities are more limited—and there is no mandate to provide them. The negotiators of the INF Treaty in the 1980s had detailed knowledge of warhead and delivery vehicle characteristics, in general, and of INF characteristics, specifically. These characteristics informed the benchmarks and timeline for the destruction of 2,600 missiles. Today, the characteristics and measurement of modern intermediate-range forces has become a point of debate that has reached an impasse. Given advances in technology, it may also represent a moving target for scientists and engineers tasked with designing technical verification measures. Russian allegations related to U.S. missile defence systems, for example, reveal the extent of the problem in deciding where intermediate-range forces begin and end. In sum, it remains unclear how to operationalize a measurable verification regime and how to build a workable institutional apparatus (à la the SVC) to support it.

Third, the sunset of the verification regime has meant that the scope and nature of any renewed verification process are up for debate. There is, of course, no mandate within the existing Treaty framework to restart an inspection regime. But, if a new verification regime is deemed desirable, negotiators face a central question: should the INF's verification regime look the same as the historical version, or should it be replaced with something new and improved? Advances in both verification technology and techniques suggest that there may be considerable benefits to using new tools and practices. However, new methods may require different types of access throughout a missile's lifecycle across production, deployment, movement, storage, and dismantlement phases that parties may be reluctant to provide.

It is too simple an analysis to state that the INF worked when it had an information exchange and on-site inspection verification in place and stopped working when that verification mechanism disappeared. It does, however, make clear the downstream consequences of

[45]Indeed, this seemed to be the immediate focus upon the U.S. decision to renege on the agreement: Sanger, David. "A Cold War Arms Treaty Is Unraveling. But the Problem Is Much Bigger." *New York Times*, Dec. 9, 2018

design decisions taken during arms control negotiations that have an impact on enforcement of the agreement.

5.9 Verification and Patterns of Compliance

The quantitative analysis above investigates the conventional wisdom that efforts to regulate military technologies should include increasingly robust mechanisms to ensure compliance. In the process, the analysis outlined above suggests that—given the design and performance of existing nuclear arms control frameworks vis à vis patterns of compliance and using the model specifications outlined above—there is reason to question this conventional wisdom, particularly when it comes to the use of challenge inspection regimes. Indeed, the analysis suggests that there may be an n-curve in which information exchanges and on-site inspection regimes maximize compliance.

As in Chapter 4, this analysis also demonstrates the degree to which compliance outcomes vary on the basis of institutional design decisions undertaken by arms control negotiators—whether to include a verification regime or not, of what type, and which types of organization monitor the agreement. Future research ought to consider whether the patterns of compliance and variation in institutional design concerning nuclear arms control reflect broader patterns in conventional arms control and efforts to regulate conventional military technologies—expanding the N available to researchers. Alternative analyses might also consider country-agreement year rather than agreement-year as the unit of analysis to assess the role of country-level co-variates such as regime type and measures of state power that are also theorized to influence compliance via audience costs and rational calculations of the costs and benefits of abrogating an agreement. Understanding the consequences of the arms control design have consequences for considering the appropriate design of regimes moving forward—and represents a particularly important avenue of future research given the uncertainty surrounding the prospects of the existing nuclear arms control regime in the wake of INF's failure and the increasing prospect that New START will not be extended.

As noted above, these results reflect institutional design decisions facing diplomats involved in arms control discussions today—whether surrounding lethal autonomous weapons, cyber weaponry, non-lethal conventional weapons, and in efforts to reinvigorate contemporary arms control following the collapse of the INF Treaty and growing concerns that New START will not be extended. For those military technologies that are inherently difficult to identify—such as software and machine learning algorithms—the desire for an "effective verification" mechanism represents an obstacle to achieving an arms control agreement altogether.[46] Given the uneven distribution of compliance benefits associated with the inclusion of various types of various verification mechanisms, the analysis above suggests that softer agreements geared may still produce compliance benefits. Indeed, these empirical findings

[46]Both military applications of artificial intelligence and quantum technologies are discussed at greater length in the concluding chapters of this dissertation.

may be important in pointing out that compliance, drawing from historical cases, may not predicated upon creating the most stringent verification regimes possible.

To revise Reagan's proverb:
proveryay, no ne ver'—'Verify, but don't trust."

Appendix

The choice to use probit or logit models is generally considered to be one of personal preference when dealing with dichotomous outcome variables. As a reminder, OLS regressions are inappropriate as the errors from a linear probability model with dichotomous outcome variables violate homoskedasticity and normality of errors assumptions, resulting in invalid standard errors. As mentioned in Chapter 3, there is increasingly disagreement about whether these drawbacks inherent within OLS methods necessitate the use of probit or logit estimators.

Below, I carry out an identical analysis to those carried out using probit regression methods using logistic regression. The number associated with each model remains the same with those using a logistic regression denoting an L. For example, Model 1 above can be compared to Model 1L, below.

Table 5.8: Logit model results for the effect of verification regime type on compliance

	(1) Model 1L	(2) Model 2L	(3) Model 3L	(4) Model 4L
No Verification	-0.39 (0.25)			
Information Exchange		0.22 (0.25)		
On-Site Inspection			-0.01 (0.25)	
Challenge Inspection				-0.60 (0.25)**
N	1187	1187	1187	1187
Log-likelihood	-259.3	-260.1	-260.5	-257.7
Constant	2.98 (0.18)	2.69 (0.17)	2.81 (0.17)	3.03 (0.17)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5.9: Logit model results for the effect of stringency of verification mechanism on treaty compliance on agreement-year basis

	(5) Model 5L	(6) Model 6L	(7) Model 7L	(8) Model 8L
Stringency	-0.05 (0.10)	0.36 (0.13)***	-0.03 (0.10)	0.36 (0.13) ***
Multilateral		1.02 (0.37)***		1.00 (0.34)***
Sunset		1.51 (0.63)**		1.73 (0.76)**
Type		-0.94 (0.14)***		-0.95 (0.14)***
Cold War			0.73 (0.34)**	0.63 (0.35)*
Successor			0.69 (0.53)	-0.48 (0.69)
N	1187	1187	1187	1187
Log-likelihood	-260.3	-226.8	-257.1	-224.4
Constant	2.87 (0.18)	4.18 (0.42)	2.64 (0.20)	4.10 (0.46)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5.10: Logit model results for the effect of verification organization type on compliance

	(9) Model 9L	(10) Model 10L
Tailored	-0.88 (0.25)***	
Intergovernmental		-0.43 (0.27)
N	1187	1187
Log-likelihood	-254.7	-259.3
Constant	3.11 (0.17)	2.92 (0.15)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As is the case in Chapter 4, the results remain the same in terms of both the sign associated with the coefficient and the statistical significance of the results—suggesting that the results are not sensitive to the choice of modeling approach.

Chapter 6

Admiring Sunsets: The Effects of Termination Clauses on Compliance

Abstract

In this chapter, I use the original Arms Control Design Dataset (ACDD) to track the design characteristics of arms control regimes on an agreement-year basis to examine the effect of termination clauses—a form of institutional flexibility—on compliance. In the process, I also point to a number of empirical examples that vary in terms of their sunset mechanisms, including the SALT Interim Agreement, START I, INF, and New START, as well as discussing the consequences of the analysis for future arms control agreements beyond nuclear weapons. The study concludes that, contrary to the conventional wisdom, agreements that have an indefinite duration have a a decreased probability of compliance.[1]

6.1 Introduction

On February 1, 2019, the United States announced its decision to withdraw from the Intermediate Nuclear Forces (INF) Treaty. Ostensibly, this decision was a response to Russian noncompliance with the Treaty following its development of its 9M729 (SSC-8) weapon system. Russia, in turn, accused the United States of violating the same Treaty by deploying missile defense systems in Eastern Europe and on February 2 announced its own withdrawal. Following Russian noncompliance with the the Conventional Forces in Europe (CFE) Treaty, the Budapest Memorandum, and U.S. withdrawal from the Joint Comprehensive Plan of Action (JCPOA) as well as concerns over the extension of New START, there are significant

[1]I would like to thank participants at UC Berkeley's Monday International Relations (MIRTH) seminar, participants in the Junior Scholars Symposium at the International Studies Association Annual Conference 2019, and participants of the Center of Strategic and International Studies' PONI Conference (December 3, 2018) for comments and feedback that have contributed to this chapter.

questions being raised concerning the viability of the existing arms control architecture.[2]

At the same time, however, there have been sustained calls for the use of arms control agreements to address the international security challenges posed by emerging technologies, from autonomous weapons and genetic engineering to cyber-attacks and space weaponry.[3] What these frameworks should look like, however, remains unclear—from "hard," formalized agreements to "softer" normative frameworks.[4]

Of the more than two hundred frameworks designed to regulate, constrain, or ban military technology, there is considerable variation in their design—particularly in terms of their scope, membership, verification mechanisms, and flexibility. The consequences of this variation, however, have yet to be systematically observed and examined—by academics or arms control negotiators.[5]

This chapter, part of a broader scientific study of the consequences of the institutional design of arms control agreements, seeks to address this gap in the literature and examines how the presence of termination clauses affect compliance with arms control agreements.[6]

- What are the relative effects of sunset mechanisms on compliance?

In the process, I adjudicate between three arguments. First, I assess whether institutional design characteristics and, by extension, termination clauses have an effect on compliance. Second, I re-examine the conventional wisdom that arms control agreements that include flexibility mechanisms like termination clauses are less likely to lead to compliance. Finally, I argue that the empirical record to date suggests that termination clauses are, in fact, more likely to lead to compliance than non-compliance.

The paper also make three contributions to the existing scholarly literature. The first is theoretical and pertains to the existing scholarship concerning the costs and benefits of including flexibility mechanisms in international cooperative mechanisms by exploring institutional design as an outcome of the bargaining phase and a driver of compliance in

[2]Kingston Reif, "After the INF Treaty, What Is Next?," *Arms Control Today* 49, no. 1 (2019): 26–29.

[3]Lewis, "The case for regulating fully autonomous weapons"; Paul Meyer, "Cyber-security through arms control: an approach to international co-operation," *the RUSI Journal* 156, no. 2 (2011): 22–27; Allan Dafoe, "AI Governance: A Research Agenda," *Governance of AI Program, Future of Humanity Institute, University of Oxford: Oxford, UK*, 2018,

[4]Joseph S Nye, *The regime complex for managing global cyber activities* (Centre for International Governance Innovation / Catham House, 2014); Alex Grigsby, "The end of cyber norms," *Survival* 59, no. 6 (2017): 109–122; Urs Gasser and Virgilio AF Almeida, "A layered model for AI governance," *IEEE Internet Computing* 21, no. 6 (2017): 58–62; Ingvild Bode and Hendrik Huelss, "Autonomous weapons systems and changing norms in international relations," *Review of International Studies* 44, no. 3 (2018): 393–413.

[5]The absence of a robust discussion pertaining to the causes and consequences of arms control agreements have contributed to a reliance upon the heuristic inclinations of arms control negotiators as they take part in arms control negotiations. In a series of interviews with previous U.S. and British negotiators of SALT I, START I, CFE, SORT, and NPT extension, the personal and past experience of the negotiators in the room was consistently heralded as a driver of the success in terms of reaching an agreement and of driving the inclusion of various design characteristics in the agreements themselves.

[6]I use the terms "termination clauses" and "sunset mechanisms" interchangeably throughout the paper.

the enforcement phase between state parties. The second is methodological as I introduce a third application of an original Arms Control Design Dataset for scholarly inquiry in which a number of design characteristics related to the inclusion of termination clauses, escape clauses, membership, types of verification regime, and agreement scope are coded for the first time. These characteristics included in the ACDD also represent a clearer coding criteria than the categorical approaches taken to coding arms control agreements in the past that aggregate institutional characteristics and introduce a source of inter-coder disagreement.[7] The third contribution is policy-oriented insofar as debates surrounding the regulation and governance of strategic arms might also contribute to academic and policy debates concerning the challenges posed by emerging technologies—from hypersonic weapons to quantum computing.

In the following sections, I examine the existing theoretical approaches to problems of compliance related to arms control. I then describe the variables to be measured and outline the research design to address the effects of termination clauses on compliance. Finally, I conclude that termination clauses, contrary to conventional wisdom, contribute to compliance. A number of empirical examples—including SALT I, INF Treaty, START I, New START, and the NPT—are included throughout.

6.2 Institutional Design and Arms Control

The academic debate surrounding the effects of international institutions has been driven, in large part, by whether and how institutions shape state behavior.[8] As a result, much of the existing literature concerning the design of international institutions and their effects upon international cooperation have leveraged comparatively rich empirical examples of international cooperation concerning economic cooperation—engaging with debates concerning compliance with GATT/WTO rulings and state participation in supranational institutions—and environmental agreements.[9] The same is true of existing work related to escape clauses that allow states to leave an agreement—and of which sunset clauses represent a subset.[10]

Building upon existing theoretical and empirical advancements and following the example of Kreps—who first explored the institutional design of arms control in the context of the

[7]Kreps and Arend, "Why States Follow the Rules: Toward a Positional Theory of Adherence to International Legal Regimes."

[8]Mearsheimer, "The false promise of international institutions"; Keohane and Martin, "The promise of institutionalist theory."

[9]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, "Loosening the ties that bind: A learning model of agreement flexibility"; Koremenos, Lipson, and Snidal, "The rational design of international institutions"; Mattli and Woods, *The politics of global regulation*; Young, *Compliance & public authority: A theory with international applications*; Mitchell, "Problem structure, institutional design, and the relative effectiveness of international environmental agreements."

[10]Pelc, "Seeking escape: The use of escape clauses in international trade agreements"; Rosendorff and Milner, "The optimal design of international trade institutions: Uncertainty and escape."

role of legalization in driving the entry into force of agreements—this broader project asks the question of whether design parameters theorized to affect state behavior in the realm of "low politics" have effects in the domain of "high politics."[11]

6.2.1 Existing Theory

Compliance under conditions of anarchy—particularly related to government decisions concerning their security—has long been a focus of international relations scholarship.[12] This scholarship varies in terms of its focus, with much existing research examining trade, environmental, and economic agreements. While this is understandable given the relatively high number of these types of agreements, it perhaps ignores the class of agreements that are most difficult to reach—that is, cooperative frameworks pertaining to security concerns. Indeed, scholarly inquiry into the causes and consequences of arms control agreements have been altogether more rare and have tended to focus on individual case studies of specific agreements, historical accounts, and future-oriented policy prescriptions rather than empirical inquiry.[13] From these studies, there are two broad arguments concerning the consequences of arms control. The first argument is that is has little to no effect on the conduct of states. The second is that under certain conditions, it offers a tool that can successfully control an arms race between nations. Below, I examine each broad argument in turn.

6.2.2 Epiphenomenal Arms Control Theory

Privileging relative gains concerns and characterizing the relations between states as a Prisoner's Dilemma in which trust is difficult to achieve, realist scholars have tended to be skeptical concerning the role of arms control, specifically, and international institutions, in

[11]Kreps, "The institutional design of arms control agreements."

[12]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Simmons, "Treaty compliance and violation"; Simmons, "International law and state behavior: Commitment and compliance in international monetary affairs"; Tomz, *Democratic default: Domestic audiences and compliance with international agreements*; Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements"; Mitchell, "Regime design matters: intentional oil pollution and treaty compliance"; Muller, "Compliance politics: A critical analysis of multilateral arms control treaty enforcement"; Chayes and Chayes, "Compliance without enforcement: state behavior under regulatory treaties"; Chayes, "An inquiry into the workings of arms control agreements."

[13]Chayes, "An inquiry into the workings of arms control agreements"; Burns, "Arms Control and Disarmament"; Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements"; Adler, "The emergence of cooperation: national epistemic communities and the international evolution of the idea of nuclear arms control"; Croft, *Strategies of arms control: a history and typology*; Daalder, "The future of arms control"; Fuhrmann and Lupu, "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty"; Gallagher, "Bridging the gaps on arms control"; Krause and Latham, "Constructing non-proliferation and arms control: The norms of Western practice"; Ranger, *Arms and Politics, 1958-1978: Arms Control in a Changing Political Context*; Nye, "Arms control after the cold war"; Trachtenberg, "The Past and Future of Arms Control"; Schelling, "What went wrong with arms control?"

general..[14] Valentino, Huth, and Croco, for example, contend that "whatever pressures toward restraint these treaties may exert on their signatories appear to be overwhelmed by the strategic incentives that combatants face to prevail and limit the costs of war to their own citizens.[15] Similarly, Bohlen argues that "treaties are powerless to deter determined cheaters, in part because they lack enforceable sanctions for violations."[16] Following this line of argument, a number of analysts and policy-makers continue to argue that arms control has been, and will always be, a dangerous illusion.[17] These scholars, perhaps unsurprisingly, rarely take the institutional design of arms control agreements into account in their scholarship.

6.2.3 Utilitarian Arms Control

By contrast, others have argued that arms control agreements, like other forms of cooperation, can offer tangible benefits to participants and that when they do, we should expect them to be created—even among adversaries.[18] Schelling alludes to the inherent cooperative structure of these arrangements as "games in which, though the element of conflict provides the dramatic interest, mutual dependence is part of the logical structure and demands some kind of collaboration or mutual accommodation."[19] What are these benefits? According to Schelling and Halperin, arms control frameworks have three goals: to reduce the probability of war by reducing uncertainty and crisis instability, to reduce the cost of war, and to reduce the cost of preparing for war.[20] In discussions with former arms control negotiators, they note that negotiations have primarily focused on the ability of arms control to contribute to crisis stability by allowing for greater predictability during crises.[21] Yet others posit a more tautological pursuit of arms control not for its benefits but as an end in itself: "the 'arms race' is commonly believed to be a major cause of international tension; it follows that the "control of the arms race" is to be sought as a kind of end in itself."[22] Scholars of institutional design—of both functionalist and rational persuasions—have considered how the design characteristics of international agreements reflect these utilitarian considerations. Others have

[14]Jervis, "Cooperation under the security dilemma"; Waltz, *Theory of International Politics*; Van Evera, "The cult of the offensive and the origins of the First World War"; Mearsheimer, "The false promise of international institutions."

[15]Valentino, Huth, and Croco, "Covenants Without the Sword International Law and the Protection of Civilians in Times of War."

[16]Bohlen, "The rise and fall of arms control."

[17]Gray, "Arms control does not control arms."

[18]Bull, "The Control of the Arms Race: Disarmament and Arms Control in the Missile Age.(Studies in International Security, II.)"; Keohane and Martin, "The promise of institutionalist theory"; Hansen, "Taking ambiguity seriously: Explaining the indeterminacy of the European Union conventional arms export control regime"; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions"; Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

[19]Schelling, "The strategy of conflict. Prospectus for a reorientation of game theory."

[20]Schelling and Halperin, "Strategy and Arms Control."

[21]Interview with Amb. Linton Brooks, March 19, 2018.

[22]Trachtenberg, "The Past and Future of Arms Control."

also suggested that existing institutions adapt to new circumstances with shifting priorities and institutional structures that reflect these utilitarian considerations.[23]

In the section below, I consider how this existing theoretical literature interacts with theory concerning arms control design.

6.3 Designing Arms Control

Scholars have long noted the considerable variation in the design of international agreements—whether related to their "bindingness," formalization, membership, and degree of legalization.[24] This variation has driven questions related to why they occur (causes) as well as what effects they might have (consequences). In this paper, I focus on the latter question of how institutional design parameters affect state behavior.

Among arms control agreements, specifically, I point to the considerable variation across a number of parameters. These include the scope, membership, enforcement, and flexibility mechanisms.

In terms of scope, described in greater detail in Chapter 4, some arms control agreements such as the Chemical Weapons Convention have been designed to ban the production of entire categories of weapons while others like New START apply limits to the number of strategic arms that the United States and Russia can deploy. Yet other agreements ban the testing of weapons like the Limited Test Ban Treaty (LTBT) or the export of technology related to particular weapons such as the Nuclear Suppliers Group and the Missile Technology Control Regime (MTCR).

There is also considerable variation when it comes to membership in arms control regimes—described in Chapter 7. While many adversarial agreements like the Interim Agreement Between The United States of America and The Union of Soviet Socialist Republics on Certain Measures With Respect to the Limitation of Strategic Offensive Arms (SALT I) created during the Cold War are bilateral and involved the United States and USSR—latterly Russia—there are also a number of examples of multilateral agreements, including the Nuclear Non-Proliferation Treaty (NPT), Biological Weapons Convention, Partial Test Ban Treaty, and COCOM designed to address strategic arms.[25]

The presence and types of monitoring, verification, and enforcement regimes included in arms control agreements also vary widely and as the subject of the preceding chapter. A large number of agreements—starting with the U.S.-Soviet Interim Agreement, also known

[23] Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting.*

[24] Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Kahler, "Multilateralism with small and large numbers"; Raustiala, "Form and substance in international agreements"; Vabulas and Snidal, "Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements"; Abbott and Snidal, "Hard and soft law in international governance"; Koremenos, Lipson, and Snidal, "The rational design of international institutions."

[25] The ACDD assigns membership type to the agreement at signing and updates the agreement vis á vis its design parameters in each agreement-year.

as SALT I—include only a promise not to interfere with the other parties' efforts to employ their "national technical means" (NTM) of verification, which is a euphemism for the use of measurement and signals intelligence (MASINT), image intelligence (IMINT) provided by satellite or aerial photography, and seismic or acoustic intelligence. Beyond NTM, agreements can also include rules and procedures for information exchanges that allow an additional data point to verify compliance with an agreement. As well as external monitoring, agreements also variously include provisions for internal monitoring. For example, a number of agreements include mechanisms for routinized, on-site inspections of designated military facilities. Perhaps most intrusive, challenge inspection regimes allow a state party to an agreement to provide a list of facilities for inspection at short notice. To address the rules and procedures associated with enforcement, a number of agreements, including the Anti-Ballistic Missile (ABM) Treaty, SALT I, START I, and the NPT, created processes through which the rules, procedures, and conclusions associated with a specific enforcement regime could be discussed. The Standing Consultative Commission (ABM), Joint Compliance and Inspection Commission (START), and Special Verification Commission (INF) each serve as examples of organizations used for this purpose.

While the design characteristics noted above are no doubt important, in this chapter I focus on the presence of mechanisms designed to give an arms control agreement flexibility. There are a variety of flexibility provisions related to agreement design including optional protocols that add to state obligations in relation to an agreement, reservations that abrogate the responsibility of a state party to a specific aspect of an agreement, escape clauses that set out a process for a state party to withdraw from an agreement, and termination clauses that designate a date on which the responsibilities of the state party to a treaty will end.

Of these flexibility provisions, some have comparatively little variation—reservations and optional protocols are exceedingly rare and escape clauses omnipresent.[26] As an example of the latter, Article XV (par. 2) of the INF Treaty reads, "Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to withdraw to the other Party six months prior to withdrawal from this Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests." The existence of termination clauses, however, vary both in terms of their inclusion and in terms of their length among arms control agreements. Existing scholarship focusing on environmental and economic issues suggests that these flexibility mechanisms should make agreements easier to reach but also potentially lead to opportunities for abuse.[27] In the section below, I examine why.

[26]Escape clauses are often included in the penultimate or final article in an agreement and provide the process through which a state party can withdraw from an agreement.

[27]Rosendorff and Milner, "The optimal design of international trade institutions: Uncertainty and escape"; Koremenos, "Loosening the ties that bind: A learning model of agreement flexibility"; Pelc, "Seeking escape: The use of escape clauses in international trade agreements."

6.3.1 Cooperation Theory and the Shadow of the Future

Cooperation theorists drawing on liberal theory theorize that a longer shadow of the future makes cooperation sustainable and, thus, more likely by increasing.[28] This theory suggests that longer interactions reinforce reciprocity between the parties to an agreement. In the context of arms control, longer agreements should allow for trust-building and reciprocity in terms of practice (from the provision of data using information exchanges or institutionalized arms reduction processes).

A large number of arms control agreements reflect this conventional wisdom by placing significant commitments upon states during the enforcement phase of agreements via inflexible agreements of indefinite duration. Contemporary debates concerning the appropriateness or inappropriateness of creating non-binding codes of conduct for outer space activities and cyberspace activities reflect this conventional wisdom. Critics of such frameworks have suggested that while these types of regimes may be easier to create, they are impossible to enforce—and consequently won't affect state behavior.

In "Bargaining, Enforcement, and International Cooperation," however, Fearon argues instead that the shadow of the future—necessary for the sustenance of international agreements—presents states with a double-edged sword. In the paper, Fearon identifies the diverging interests within players strategies across two temporal phases of conflict: the *bargaining phase* and *enforcement phase*. Fearon notes that decisions taken by states parties to increase the likelihood of success during the bargaining phase have a negative effect on the enforcement phase of a game, and vice versa—representing a "bargaining and enforcement paradox." This paradox can explain the difficulty of reaching cooperative agreements and of reaching agreements that last in perpetuity.[29]

To make this theoretical argument salient in terms of arms control, the bargaining and enforcement paradox suggests that efforts to minimize state obligations during the negotiation phase by allowing for reservations, escape clauses, termination clauses, and minimizing a commitment to verification *increase* the likelihood of an agreement being signed. However, these same features *decrease* the chances of regime survival as states leave the agreement or cheat.[30]

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[28] Axelrod and Keohane, "Achieving cooperation under anarchy: Strategies and institutions"; Duncan Snidal, "Coordination versus prisoners' dilemma: Implications for international cooperation and regimes," *American Political Science Review* 79, no. 4 (1985): 923–942; Kenneth A Oye, "Explaining cooperation under anarchy: Hypotheses and strategies," *World Politics* 38, no. 1 (1985): 1–24; Robert Axelrod and Douglas Dion, "The further evolution of cooperation," *Science* 242, no. 4884 (1988): 1385–1390.

[29] Fearon measures this difficulty by using the time taken to reach an agreement as a proxy for the bargaining challenge with those agreements that take longer to achieve designated as representing a more difficult bargaining process.

[30] As in all cases of international cooperation, in arms control "there are multiple self-enforcing agreements or outcomes that two of more parties would all prefer to no agreement, but the parties disagree on their ranking of the mutually preferable agreements."Fearon, "Bargaining, enforcement, and international cooperation." See also: John F Nash Jr, "The bargaining problem," *Econometrica: Journal of the Econometric Society*, 1950, 155–162; Thomas C Schelling, *The strategy of conflict* (Harvard University Press, 1960).

Table 6.1: Sunsets vs. Compliance (Examples)

	Compliance	*Noncompliance*
Sunset	START I; New START	NPT (pre-1995)
No Sunset	PTBT; Hotline Agreement	INF Treaty; ABM Treaty

In the analysis below, I find empirical support for Fearon's proposition that the shadow of the future is not necessarily the driver of positive externalities proposed by cooperation theorists.

6.4 Hypotheses

In the section below, I consider a series of hypotheses associated with the theories concerning the effect of including a flexibility mechanism within an arms control agreement.

On the question of whether flexibility provisions should yield higher rates of compliance, the realist scholars noted above tend to suggest that institutional design is of little consequence, thus termination clauses should have no meaningful effect on compliance. This offers the null hypothesis:

- H_0 Termination clauses have *no effect* on patterns of compliance and noncompliance.

As noted above, the conventional wisdom that flexibility provisions such as termination clauses decrease levels of compliance by increasing the incentive to cheat and by reducing the shadow of the future and endogenously signaling a lack of commitment to the agreement prior to signing. This yields the following hypothesis:

- H_1: If an agreement includes a termination clause, then compliance is *less* likely.

However, a cursory glance at the empirical record yields two observations. First, while a majority of arms control agreements include escape clauses that address state party withdrawal—as mentioned above—relatively few have a prescribed date at which the states parties are no longer bound by the agreement—a sunset or termination clause. And second, of those agreements that do include a termination agreement, a large number have been relatively successful—particularly those designed to reduce the number of strategic warheads and their delivery systems from SALT I to New START.

This observation leads to an alternative hypothesis:

- H_2: If an agreement includes a termination clause, then compliance is *more* likely.

While the question of why flexibility mechanisms might increase the likelihood of compliance is under-theorized, theory from political psychology concerning optimism bias regarding the perceived prospects of state capacity at the time of renegotiation perhaps best underpins

H_2. Put another way, the shadow of the future is discounted by parties to an agreement when they perceive that a future agreement is more likely to be to their benefit than the current agreement given the expectation that they are going to be in an improved bargaining position relative to other states parties in future negotiations. This "optimism bias" that conditions might subsequently overcomes the negative prospects for the enforcement phase of an agreement.[31,32]

In the next section, I use the original Arms Control Design Dataset (ACDD) to test whether termination clauses that make agreements easier to reach lead to diminishing returns for compliance using the Arms Control Design Dataset. In the analysis of existing strategic arms control frameworks, I find support for H_2.

6.5 The Arms Control Design Dataset

To address the question of how sunset mechanisms impact compliance, I use a dataset of all strategic arms control agreements that have been negotiated and entered into force between 1945 and 2019. The dataset is composed of cross-sectional panel data for longitudinal analysis.

6.5.1 Introducing the Arms Control Design Dataset

For the purposes of this chapter, I use a subset of strategic arms control agreements that entered into force from Kreps' list of agreements used to examine the drivers of ratification and non-ratification as the case selection criteria. [33] While this subset does not include agreements that deal with other strategic threats such as the Chemical Weapons Convention or those agreements with secondary strategic consequences such as the Open Skies Treaty, it provides a useful tool for case selection with the intention of minimizing researcher-introduced bias. It also allows for a comparison across a number of alternative categorical variables related to nuclear weapons that are correlates of compliance.

[31]Tali Sharot et al., "Neural mechanisms mediating optimism bias," *Nature* 450, no. 7166 (2007): 102; Ronald R Krebs and Aaron Rapport, "International relations and the psychology of time horizons," *International Studies Quarterly* 56, no. 3 (2012): 530–543; Emilie M Hafner-Burton et al., "The behavioral revolution and international relations," *International Organization* 71, no. S1 (2017): S1–S31.

[32]There may also be normative, reputation-based, and domestic politics argument to be made regarding the high costs of withdrawing from an agreement in both levels of a state leader's "two-level game." Putnam, "Diplomacy and domestic politics: the logic of two-level games"; Branislav L Slantchev, "Politicians, the media, and domestic audience costs," *International Studies Quarterly* 50, no. 2 (2006): 445–477 It is also worth considering the marginal gains of withdrawing from an agreement that includes a termination clause and that will end in due course without a state party having to endure the costs of withdrawal.Miller, "Politics over promise: Domestic impediments to arms control"

[33]Kreps, "The institutional design of arms control agreements" This list also reflects those compiled by the Nuclear Threat Initiative, Federation of American Scientists, and Goldblat's earlier work to detail the treaty commitments included within each arms control framework.Goldblat, *Arms control: a survey and appraisal of multilateral agreements*; Goldblat, *Arms Control: The New Guide to Negotiations and Agreements.*

Of the 48 agreements considered by Kreps, I leave out those that never entered into force and those that are institutions rather than agreements in this analysis. For example, while both the United States and USSR signed the SALT II Agreement designed to cap strategic forces and curtail development of new missiles in 1979, it was not ratified by the United States in response to the Soviet invasion of Afghanistan and subsequently expired in 1985 without entering into force. As a result, I do not include that agreement or those like it including the Antisatellite Agreement of 1978 and START II.[34] As noted in previous chapters, the primary justification for this decision is that states cannot be reasonably expected to comply with agreements that never entered into force—even if they made the decision to sign them. Using this case selection criteria, the dataset used in this chapter include 40 agreements comprising 1,187 agreement-years.

Below, I introduce the variables coded within the Arms Control Design Dataset and used in the quantitative analysis to follow.

6.5.2 Termination Clauses

The coding criteria for the design parameters of arms control agreements included in the study call for an analysis of the use of specific language included in the treaty text. Article XIV, par. 2 of New START serves as a useful example: "This Treaty shall remain in force for 10 years unless it is superseded earlier by a subsequent agreement on the reduction and limitation of strategic offensive arms." For the purposes of this chapter, the sunset mechanism is treated as a dichotomous variable signaling the inclusion or omission of a termination clause.[35]

There are several examples of agreements that include termination clauses that outline the length of an agreement. The Nuclear Nonproliferation Treaty included a 25-year sunset clause upon its entry into force in 1970 that concluded in 1995. Interestingly, the international community made the decision to extend the NPT's treaty provisions indefinitely upon reach that milestone. Most adversarial arms control agreements that involve a cap on nuclear warheads and delivery vehicles similarly include a sunset mechanism. SALT I, for example include a series of five-year sunsets that were renewed three times before lapsing in 1985. New START, which entered into force in 2011, also includes a 10-year sunset clause, with the potential for parties to renew prior to the end of the performance period in 2021 for a further five years.[36]

[34]I also do not include the IAEA. While it does provide a role managing nuclear safeguards under the NPT and a monitoring role for other agreements it does not, in my estimation, constitute an arms control agreement in and of itself.

[35]There is a second variable for analysis in future work that tracks the number of years until termination that can be used to assess the marginal effects of the distance to agreement on compliance outcomes.

[36]Whether the United States and Russia will, in fact, extend or engage in future efforts to limit their nuclear weapons numbers has been the subject of fierce debate amid fears that arms control may cease to exist altogether.Manzo, *Nuclear Arms Control Without a Treaty? Risks and Options After New START*

For the negative cases, agreements that do not include termination clauses usually include a provision noting the "unlimited duration" of the agreement as well as the withdrawal process clause described above.[37]

6.5.3 Control Variables

In the quantitative analysis, below, I also include a number of control variables that may account for compliance or non-compliance. Among these are a number of alternative design parameters including whether they are bilateral or multilateral, a dichotomous measure of whether there is a verification regime embedded within the agreement, a series of dichotomous variables associated with specific verification mechanisms, as well as categorical measures of verification, scope, and obligation—or "bindingness"—drawn from Kreps's work. These categorical variables are constructed by scoring each agreement in terms of its institutional design parameters:
`Obligation`—Degree of agreement's binding nature:

- 0 for "gentleman's handshake";
- 1 for formally binding;
- 2 for no reservations, declarations, understandings; and
- 3 no escape clauses.

`Precision`—Specificity of requirements embedded in agreement:

- 0 for aspirational in terms of numbers, behavior, timelines;
- 1 for specificity in terms of arms control behavior (e.g., action required on testing, whether states can develop weapons or not); and
- 2 for specificity in arsenal numbers, thresholds, delivery vehicles, timelines for reaching objectives.

`Delegation`—Degree to which states assign authority for the enforcement of the agreement to third parties:

- 0 for no outside agency delegation, inspections, or specified monitoring;
- 1 for reporting of compliance through regular meetings or information exchanges;
- 2 for monitoring through states National Technical Means; and

[37]Where treaty language is unclear, cases are dropped from the sunset column—though this is not the case among those agreements included for analysis in this paper.

- 3 for verification through on-site inspections.[38]

This analysis presents a useful comparison of methods designed to test dichotomous variables compared to categorical variables. Indeed, one of the methodological choices made in the process of conducting this study was to reduce the potential for inter-coder reliability problems by reducing the need for relative scoring metrics. For example, the criteria in the `obligation` variable above are clear in terms of the difference between a formally binding agreement (scored as a 1) and a "gentleman's handshake" (scored as a 0) but less clear in their attempt to address subsidiary obligations—particularly as escape clauses are ubiquitous in formally binding arms control contexts.

The analysis also includes a dummy variable accounting for the Cold War time period in which an agreement-year occurs and another accounting for whether the agreement builds on an existing arms control agreement.[39] There are a number of theories that point to the relationship between the Cold War and compliance. On the one hand, compliance may be more likely given the stable nature of the strategic competition between the United States and USSR and the preponderance of power in Washington and Moscow that conditioned third-party state compliance. On the other, compliance may be less likely (and allegations of non-compliance more likely) during Cold War agreement-years given the adversarial relations between the two superpowers whose relationship ebbed and flowed during the Cold War period.

6.5.4 Dependent Variable: Measuring Compliance

Unlike treaty obligations that are spelled out in agreements and treated dichotomously and temporally in the dataset, coding compliance involves taking into account allegations of breaches from historical, journalistic, and government records.[40] Where available, I use accounts in popular U.S. and international presses to corroborate noncompliance on an agreement-year and country-agreement-year basis. For example, the construction of the Yeniseysk-15 phased array radar at Krasnoyarsk in 1980 led to allegations by the United States in 1983 that the USSR was in violation of its commitments to the ABM Treaty. More recently, Russian deployment of the 9M729 on the Iskander launcher in 2008 represented a breach of the INF Treaty. Russia, in response, argued that U.S. missile defense forces were also in breach of the Treaty. Compliance, for the purposes of this study, relates to a best estimation of states abiding by the letter of their agreements.[41]

[38]Kreps, "The institutional design of arms control agreements."

[39]Ibid.

[40]The coding criteria for measuring compliance is discussed at greater length in Chapter 3. The coding criteria for the dependent variable is also consistent across the chapters—and is included in each for the benefit of the reader and to go alongside the discussion of measurement concerning each independent variable of interest.

[41]Where possible, each episode of compliance is cross-referenced against chapter 9, "Compliance and Noncompliance," in Richard Burns' *Evolution of Arms Control.*Duffy, "Arms control treaty compliance"; Burns, *The evolution of arms control: from antiquity to the nuclear age*

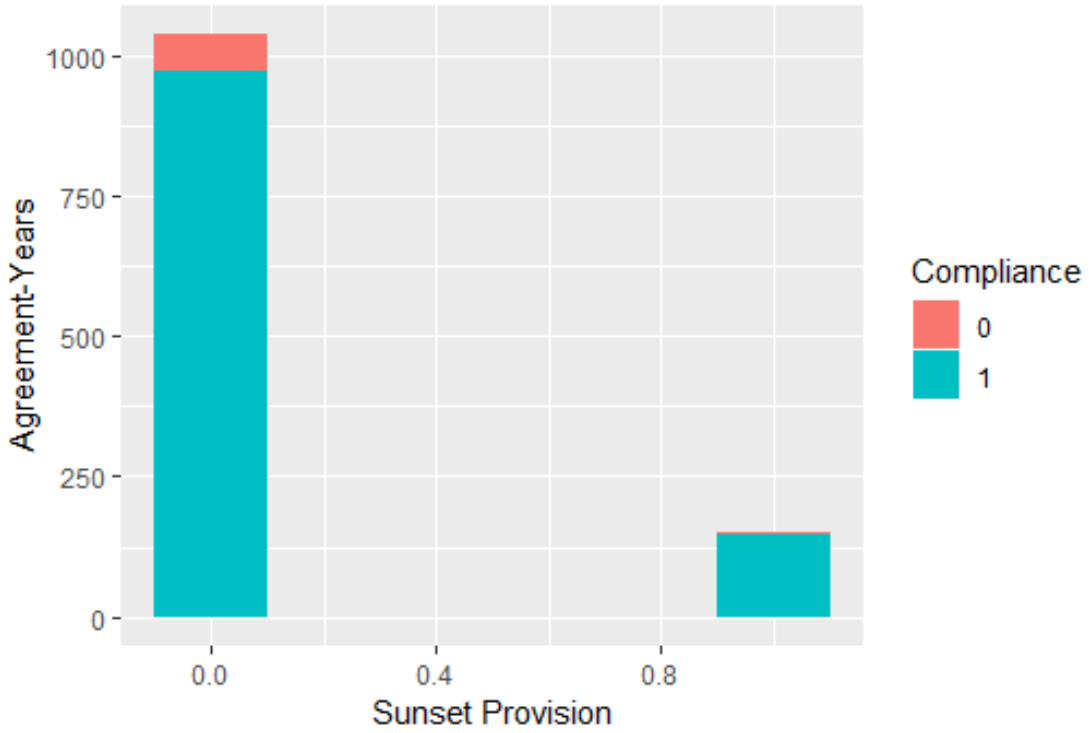

Figure 6.1: The figure above provides descriptive statistics related to those agreement-years that are coded as including sunset provisions (on left) and those that do not (on the right). Those that are blue are compliance-years while those marked as red are noncompliance-years.

Within the dataset, there are a number of episodes of noncompliance from the 1980s onwards related to actions undertaken by Russia, the United States, North Korea, Iran, India, and Pakistan regarding their respective treaty commitments.

6.6 Quantitative Analysis

In this section, I use the dataset described above to analyze 1,187 agreement-years among arms control agreements that have entered into force. The first analysis is composed of four probit models.

6.6.1 Probit Regression Analysis

As the dependent variable, compliance, is dichotomous, I use a probit regression model to consider the effect of those agreements with and without termination clauses on compliance:[42]

[42]A probit model uses a cumulative distribution function of the inverse standard normal distribution to define f (*)—rescaling the values of the dependent variable to fall between 0 and 1. Hence, whatever

$$\hat{Y} = f(\alpha + \beta x) \tag{6.1}$$

In this model, $\hat{Y}$ is a predicted probability of compliance given the presence or absence of a sunset mechanism, x. The findings yielded across a number of modeling specifications are summarized in Table 1, below.[43]

Table 6.2: Probit models examining the effect of termination clauses on treaty compliance on agreement-year basis

	(1) Model 1	(2) Model 2	(3) Model 3	(3) Model 4
Sunset	0.52 (0.24)**	0.56 (0.27)**	1.00 (0.26)***	1.05 (0.34)***
Multilateral		0.35 (0.17)**		0.36 (0.17)**
Verification		0.73 (0.18)***		
Agreement Type		-0.50 (0.07)***		-0.11 (0.10)
Cold War				0.27 (0.18)
Successor				0.13 (0.32)
Obligation			0.92 (0.19)***	0.85 (0.23)***
Precision			-0.42 (0.12)***	-0.35 (0.13)***
Delegation			-0.73 (0.10)***	-0.65 (0.13)***
N	1187	1187	1187	1187
Log-likelihood	-257.7	-222.2	-195.6	-191.2
Constant	1.53 (0.06)	2.29 (0.19)	2.57 (0.19)	2.35 (0.24)

Due to the fact that Kreps's *delegation* variable includes verification mechanisms, the two variables are run separately and the latter is left out of Model 4.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The first model regresses the presence of a sunset mechanism upon compliance and finds that termination clauses have a statistically significant ($p < 0.05$) and positive effect upon the predicted probability of compliance, providing support for H_2. The finding is also in line with a qualitative examination of successful agreements such as SALT I, START I, SORT, and New START designed to set limits on nuclear warheads with explicit timelines for elimination of material as well as for the termination of the agreement. Indeed, many of these agreements have led to successor agreements with the goal of continuing the draw-down of strategic assets by Moscow and Washington.

The second model controls for additional design characteristics of arms control agreements—their membership, type of verification regime, and type of agreement itself. The model finds

$\alpha + \beta x$ equals, it can be transformed by the function to yield a predicted probability of compliance on an agreement-year basis. Alternative model specifications for are included in the Appendix.

[43]These results are consistent with an analysis using alternative modeling approaches. In the Appendix to this chapter, I include a parallel analysis using logistic regression rather than the probit model described here.

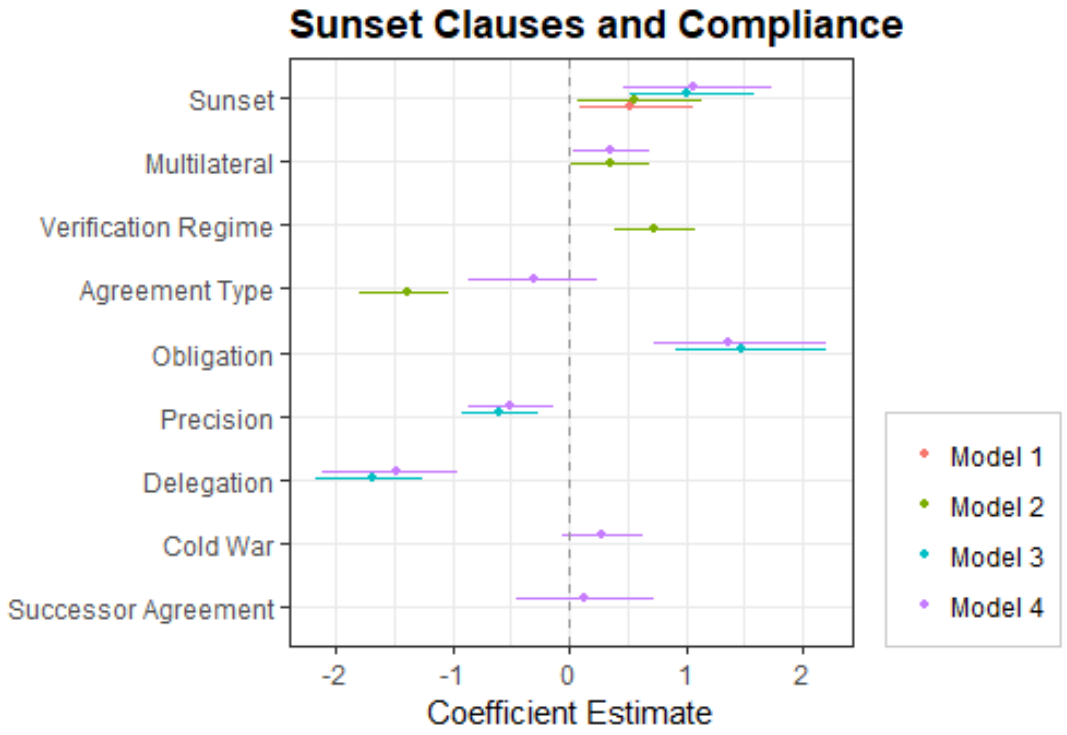

Figure 6.2: This figure graphs the results of the probit regression equation in Table 6.1.

once again that termination clauses have a positive and statistically significant effect upon the predicted probability of compliance—providing further support for H_2. Dichotomous measures for multilateral agreements and the inclusion of verification regimes have a similarly positive and statistically significant effect.[44] As discussed in Chapter 4, the categorical agreement type variable that distinguishes between technology control, test bans, arms limitations, and arms prohibitions has a negative effect on compliance as the agreements move from commitments that are easier for states to make to those that are more difficult.

The third model controls for a series of categorical variables that address the degree of formality associated with an agreement (`obligation`), the scope of the agreement in terms of the action required of states that are party to the agreement (`precision`), and an alternative calculus of verification (`delegation`).[45] Within the model, sunset mechanisms and increased formality of an agreement have positive and statistically significant effects upon compliance while precision and increased levels of delegations have a negative effect upon the predicted probability of compliance.

Finally, I include additional control variables theorized to impact the predicted probability of compliance in Model 4. In the model, the previous results remain the same. The model,

[44]Chapter 5 dives more deeply into the verification finding while Chapter 7 address membership issues.
[45]Each of these variables are described in detail above

Table 6.3: This table notes the variation in the predicted probability of compliance for a given agreement-year on the basis of the inclusion of a termination clause in the treaty design using Models 1-4 and holding all control variables at their mean value.

Model	**No Sunset**	**With Sunset**
Model 1	93.7 %	98.0 %
Model 2	96.1 %	99.0 %
Model 3	97.5 %	99.8 %
Model 4	97.3 %	99.8 %

intuitively, suggests that adversarial agreements have a decreased probability of compliance while successor agreements have a positive effect on the probability of compliance—both without statistical significance. The variable denoting the Cold War has a positive though statistically insignificant effect on compliance—a finding worthy of further examination in future work that considers the structural environment in which arms control agreements are reached.

The predicted probability of compliance in any agreement-year can also be calculated using the coefficients noted in Table 6.1 to examine the effect of termination clauses on compliance holding each of the control variables at their mean value.

For example, for Model 2:

$$\hat{Compliance} = F(2.29 + 0.56(\texttt{Sunset}) + 0.35(\texttt{Multi}) + 0.73(\texttt{Ver}) - 0.50(\texttt{AgreementTyp})) \tag{6.2}$$

where F is the cumulative distribution function of the inverse standard normal distribution and 1 is the value of $\hat{Y}$ associated with compliance.

This equation allows us to calculate the predicted probability of compliance for each type of agreement on an agreement-year basis holding each of the co-variates at their mean value.[46] These results are reported in 6.3 and reflect the probit regression results above.

The results suggest that while the probability of compliance with arms control commitments is high on an agreement-year basis, the addition of termination clauses has an effect at the margins.

Across each of the analyses above, the inclusion of sunset clauses has a positive and statistically significant effect on compliance outcomes.

[46]The equation can also be used to calculate the likelihood of compliance given a variety of design characteristics. For example, once could consider the relative effect of an agreement that is bilateral, includes a verification regime, does not include a termination clauses, with entry into force following the Cold War to calculate the predicted probability of compliance in any given agreement-year.

Table 6.4: This table shows the Variance Inflection Factor for the probit model including all four design variables and the Cold War and Successor control variables used in Model 2, above.

Variables	*Sunset*	*Agreement Type*	*Multilateral*	*Verification*
VIF	1.08	1.69	1.43	1.96
1.04	1.68			

6.7 Sensitivity Analysis

In this section, I perform a series of sensitivity analyses related to the model specifications above. In particular, I focus on those findings noted in Models 1 in which the sunset dummy is modeled alone before analyzing each of the models carried out above.

6.7.1 Multicollinearity

First, I test the multicollinearity of the standard probit model. To do this, I use a variance inflation factor (VIF) to measure how easy it is to achieve the same model outcomes from a linear regression using the other predictors. The square root of the VIF tells you how much larger the standard error of the estimated coefficient is in respect to a case when that predictor is independent of the other predictors.

A general guideline is that a VIF larger than 5 or 10 indicates that the model has problems estimating the coefficient..[47] Table **??** shows the VIF for Model 2 described above. I use Model 2 as it considers the effect of the presence of a termination clause on the predicted probability of compliance on an agreement-year basis alongside the other institutional design co-variates. In this case, the co-variates are the categorical agreement type variable and dummy variables measuring whether the regime includes a verification regime and whether the regime is multilateral.

The results of this analysis suggest that multicollinearity, in which the explanatory variables are highly correlated, is not a concern for the models above.[48]

6.7.2 Independence and Heteroskedasticity Probit Results

The existing methodological literature suggests that models using panel data may internalize substantial cross-sectional dependence in the errors. This may occur due to the presence of shocks common to the data points, unobserved phenomena that ultimately become part of the error term, or temporal dependence. To address concerns surrounding the independence

[47] Thompson et al., "Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results."

[48] These results are slightyl different from those carried out in Chapters 4, 5, and 7 as Chapter 6 analyzes the presence or absence of a verification regime rather than the type of verification regime.

Table 6.5: This table shows the calculation of coefficients and robust standard errors (Huber-White) using model 1.

	Variables	**Coefficient**	**Robust Standard Error**	***p <0.05***
2***Model 1**	*Constant*	1.53	0.06	Yes
	Sunset	0.68	0.28	Yes

of both the outcome variables and the regressors, I run a series of regression models with clustered standard errors that adjust for non-independence across agreements and across years.

To do this, I assess whether circumstances in which the variability of a variable is unequal across the range of values of a second variable that predicts it exist in the underlying data used in the probit models above. This test is particularly important given that heteroskedasticity in these models can represent a major violation of the probit (and logit) model specifications, which assume homoskedastic errors.

Below, I use the probit regression equation in Model 1 to test for heteroskedasticity when using the *Sunset* independent variable, shown below:

$$\hat{Compliance} = F(1.53 + 0.52(\texttt{Sunset}) \tag{6.3}$$

Recall, the standard errors within the standard probit model associated with the constant and the sunset variable are, 0.06 and 0.24 respectively.

I subsequently calculate the Huber-White robust standard errors—also known as heteroskedasticity-consistent (HC) standard errors—reported in the Table 6.5.[49]

The results of this analysis along with the corresponding analysis for Models 2-4 are shown below.

Table 6.6: Heteroskedastic probit models examining the effect of termination clauses on treaty compliance on agreement-year basis using Huber-White robust clustered standard errors

[49]I use the *sandwich* R package to carry out this analysis.Zeileis, "Object-oriented computation of sandwich estimators"; White et al., "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity."

	(1) Model 1HP	(2) Model 2HP	(3) Model 3HP	(3) Model 4HP
Sunset	0.68 (0.28)**	0.77 (0.36)**	1.18 (0.31)***	1.16 (0.58)**
Multilateral		0.31 (0.16)*		0.34 (0.20)*
Verification		0.81 (0.18)***		
Agreement Type		-0.52 (0.06)***		-0.13 (0.10)
Cold War				0.26 (0.19)
Successor				0.21 (0.59)
Obligation			0.92 (0.11)***	0.88 (0.19)***
Precision			-0.43 (0.11)**	-0.38 (0.16)***
Delegation			-0.73 (0.08)***	-0.62 (0.09)***
N	1187	1187	1187	1187
Log-likelihood	-253.6	-216.4	-191.9	-187.4
Constant	1.53 (0.06)	2.35 (0.17)	2.58 (0.22)	2.38 (0.19)

Due to the fact that Kreps's *delegation* variable includes verification mechanisms, the two variables are run separately and the latter is left out of Model 4.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results of the heteroskedastic model remain in concert with the findings derived from the standard probit model—with the latter slightly under-estimating the magnitude of the positive effect of an agreement having a termination clause on an agreement's compliance.

6.7.3 Time Dependence

I now turn to the question of whether the findings outlined above are driven by temporal dependence.

To address this, I use Carter and Signorino's cubic polynomial approximation method described in Chapter 3 to include t, t^2, and t^3 in several regression models described above. In these models t represents the time since the last "event."[50] In this analysis, the specific event at issue is a breach of an arms control agreement. Thus, t represents the time, in years, since the last episode of non-compliance on an agreement-year basis.

Two models including t, t^2, and t^3 are reported in the Table below. The first model presents the independent variable of interest while the second includes the independent variable of interest alongside the additional design characteristics assessed in Table 6.2 above.

Table 6.7: Cubic polynomial approximation probit models for the effect of arms control agreement on treaty compliance on agreement-year basis

[50]Carter and Signorino, "Back to the future: Modeling time dependence in binary data."

	(1) Model 1	(1) Model 1CP	(2) Model 2	(2) Model 2CP
Sunset	0.52 (0.24)**	0.74 (0.35)**	0.56 (0.27)**	0.71 (0.40)*
Multilateral			0.35 (0.17)**	0.12 (0.24)
Verification			0.73 (0.18)***	0.77 (0.24)***
Agreement Type			-0.50 (0.07)***	-0.50 (0.10)***
t		1.10 (0.15)***		1.05 (0.15)***
t^2		-0.09 (0.02)***		-0.08 (0.02)***
t^3		0.002 (0.0004)***		0.002 (0.0004)***
N	1187	1187	1187	1187
Log-likelihood	-257.7	-128.2	-191.2	-111.8
Constant	1.53 (0.06)	-1.05 (0.22)	2.35 (0.24)	-0.03 (0.36)

Due to the fact that Kreps's *delegation* variable includes verification mechanisms, the two variables are run separately and the latter is left out of Model 4.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Overall, the findings reported in Table 6.7 above are consistent with the findings above. With that said, temporal dependence among observations may be strengthening the result vis /'a vis statistical significance associated with the role of termination clauses on compliance—the coefficient estimates associated with the presence of termination clauses remains positive, the p-value drops from $p = 0.02$ in Model 2 to $p = 0.07$ in Model 2CP controlling for temporal effects.

6.7.4 Selection Effects

As discussed in Chapter 3 and as Downs et al. and von Stein have noted, when an independent variable is itself a strategic choice on an outcome there are significant selection effects that must be taken into account when analyzing observational data.[51] In simplest terms, any outcome variables (in this case, compliance) must be measured against the predilection of a state taking the same action in the absence of the variable of interest (in this case an arms control agreement).

In this agreement-year-based analysis of the ACDD, the analysis does not consider that the inclusion of sunset mechanisms in an agreement as well as the underlying probability of compliance for states parties varies and that this variation affects both the choice of whether an agreement lasts indefinitely or for a fixed period of time as well as whether states comply with the agreement (absent considerations of how long an agreement might last). The analysis above, for examples, does not preclude that states might choose the agreements of indefinite duration for the hardest cases and thus that it be unsurprising that non-compliance is the result.

[51] Downs, Rocke, and Barsoom, "Is the good news about compliance good news about cooperation?"; Von Stein, "Do treaties constrain or screen? Selection bias and treaty compliance."

Thus, the findings presented in this chapter have the caveat that they provide a first cut at the causal relationship between institutional design characteristics and compliance outcomes on an agreement-year basis—not the final word concerning the causal relationship between the two.

6.8 Discussion

As outlined in the analysis above, the the empirical record provides scholars reason to question the conventional wisdom that those agreements with a longer shadow of the future offer the best avenue for reinforcing international commitments. Instead, this analysis of historical cases of predominantly nuclear arms control suggests that termination clauses *increase* the probability of state compliance with their treaty obligations.

While this analysis points to patterns in new empirical data, it also relies on historical accounts and elite interviews to discuss accounts for *why* this relationship occurs. As noted above, the existing bargaining literature offers a useful place to start when considering the result. But while cooperation theorists suggest that a longer shadow of the future is desirable, the results reported above suggest that the inclusion of termination clauses decreasing the length of time that states parties are committed to an agreement may not have deleterious consequences during the enforcement phase.

Anecdotal evidence from interviews conducted over the course of this dissertation in Washington, London, and Geneva suggest that states include termination clauses for a number of reasons beyond and including increasing the likelihood of concluding a successful negotiation. Among them is the contention that the limited period of time in which states are engaged with an agreement offer an opportunity to signal their strategic commitment embedded in the agreement—with compliance reinforcing the message of this commitment to the other player(s) and increasing the likelihood of engaging on beneficial strategic commitments moving forward. In some ways, this logic mirrors the reputation costs theory described by Tomz and others on a dyadic basis.[52] It may also be the case that the inclusion of a termination clause increases the salience of the political issue being negotiated over, increasing the relative importance of compliance. In a series of interviews focused on the question of the INF Treaty, one of the potential explanations for Moscow's decision to abrogate their Treaty commitments stemmed from the perception that Washington would be unwilling to escalate non-compliance with the INF Treaty to the level of a political crisis. Policy-makers in Washington and London suggested that the sunset of the INF's verification regime and the absence of a meeting of the SVC for over a decade served as evidence of this perceived indifference.

Another theory concerning optimism bias and its impact on negotiation offers a similar outcome but alternative logic, relying on the temporal elements of termination clauses and the effect of time on both personal and institutional decision-making. Optimism bias theory

[52]Michael Tomz, *Reputation and international cooperation: sovereign debt across three centuries* (Princeton University Press, 2012).

suggests that parties to an agreement *over-estimate* the likelihood that their bargaining position will be stronger in the future. As a result, parties comply with an agreement to reach the subsequent renegotiation of their respective treaty commitments. The large number of treaties that have been renegotiated and extended reflect this logic. A related logic suggests that states parties undertake institutional learning (in terms of what states parties can live with related to their commitments) during the course of time-bound treaties—particularly those concerning arms reduction.

This chapter also makes clear that there are substantial avenues for further research. With regard to data pertaining to arms control, expanding the agreement-year dataset to include non-strategic arms, including additional co-variates as control variables that account for alternative theoretical explanations for (non-)compliance, assessing spillover effects, tracking data from the negotiation, signing, and ratification phases of arms control agreement development, and building a country-year-agreement dataset that takes into account state-level variables that drive non-compliance such as regime type and national material capabilities theorized to affect the likelihood of a state to abide by its commitments.[53] In democracies, for example, some point to the audience costs of reneging on a commitment being larger than in non-democracies while others suggest that this finding has been exaggerated.[54]

More work is also needed to grasp the theoretical underpinnings of the paper's empirical findings—whether rooted in optimism bias, a international and domestic audience costs, or alternative explanations. Survey experiments, in which respondents address the strategic consequences of complying or reneging on arms control commitments, may offer a useful mechanism through which these causal variables might be usefully tested moving forward.

While unbounded flexibility may increase the complexity of international agreements and fail to regulate the very activities that states parties are attempting to control, this initial cut at the existing empirical data suggests that flexibility can offer substantial benefits to arms control negotiators. The analysis might also be usefully extended to include other forms of agreements including environmental, economic, trade, and financial regimes to consider a generalizeable theory concerning how flexibility mechanisms affect state behavior. A meta-analysis may also point to the differences between security-oriented cooperation agreements and other types of international cooperation.

Understanding compliance, particularly in the context of arms control, has proven a significant challenge for scholars of international relations. As the existing arms control architecture recedes and governments are forced to address the challenges posed by emerg-

[53]Monty G Marshall, Keith Jaggers, and Ted Robert Gurr, "Polity IV project: Dataset users manual," *University of Maryland*, 2002, J Michael Greig and Andrew J Enterline, "National Material Capabilities (NMC) Data Documentation Version 5.0," *Correlates of War* 27 (2017).

[54]Christopher Gelpi and Joseph M Grieco, "Attracting trouble: Democracy, leadership tenure, and the targeting of militarized challenges, 1918-1992," *Journal of Conflict Resolution* 45, no. 6 (2001): 794–817; Jessica L Weeks, "Autocratic audience costs: Regime type and signaling resolve," *International Organization* 62, no. 1 (2008): 35–64; Jessica L Weeks, "Strongmen and straw men: Authoritarian regimes and the initiation of international conflict," *American Political Science Review* 106, no. 2 (2012): 326–347; Jessica Chen Weiss, "Authoritarian signaling, mass audiences, and nationalist protest in China," *International Organization* 67, no. 1 (2013): 1–35.

ing military technologies,[55] understanding the options for replacing it are vitally important. Taking stock of the causes and consequences of efforts to constrain state behavior thus far is vitally important for the understanding both the potential and limitations of future agreements. The findings outlined in this chapter suggest that agreements with more flexibility mechanisms rather than fewer may lead to better news concerning compliance. This has real consequences for the debates surrounding how "hard" or "soft" agreements ought to be when addressing emerging technologies that are still in their nascent phases and the risk of "locking-in" regulatory mechanisms that may not be fit for purpose. With regard to efforts to regulate military technologies with strategic effects, there may be advantages to designing regimes with shorter time horizons than previously anticipated.

Appendix

The choice to use probit or logit models is generally considered to be one of personal preference when dealing with dichotomous outcome variables. As a reminder, OLS regressions are inappropriate as the errors from a linear probability model with dichotomous outcome variables violate homoskedasticity and normality of errors assumptions, resulting in invalid standard errors. As mentioned in Chapter 3, there is increasingly disagreement about whether these drawbacks inherent within OLS methods necessitate the use of probit or logit estimators.

Below, I carry out an identical analysis to those carried out using probit regression methods using logistic regression. The number associated with each model remains the same with those using a logistic regression denoting an L. For example, Model 1 above can be compared to Model 1L, below.

Table 6.8: Logit models examining the effect of termination clauses on treaty compliance on agreement-year basis

[55] Michael C Horowitz, *The diffusion of military power: Causes and consequences for international politics* (Princeton University Press, 2010).

	(1) Model 1L	(2) Model 2L	(3) Model 3L	(3) Model 4L
Sunset	1.19 (0.60)**	1.36 (0.63)**	2.03 (0.61)***	1.76 (0.73)**
Multilateral		0.76 (0.34)**		0.52 (0.33)**
Verification		1.49 (0.35)***		
Agreement Type		-1.01 (0.14)***		-0.21 (0.22)
Cold War				0.63 (0.36)*
Successor				0.70 (0.70)
Obligation			1.83 (0.44)***	1.86 (0.53)***
Precision			-0.90 (0.23)***	-0.82 (0.27)***
Delegation			-1.49 (0.21)***	-1.30 (0.27)***
N	1187	1187	1187	1187
Log-likelihood	-257.7	-221.4	-195.8	-191.4
Constant	2.70 (0.13)	4.28 (0.44)	5.03 (0.44)	4.57 (0.57)

Due to the fact that Kreps's *delegation* variable includes verification mechanisms, the two variables are run separately and the latter is left out of Model 4.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Using logistic regression rather than probit regression does not change the direction of the effect associated with any of the results noted in the chapter above. It does, however, change the statistical signficance associated with some of the models, most notably the statistical significance (at $p < .10$) of the Cold War variable in Model 4 and Model 4L.

Broadly, the results from the logit models presented here are in line with the results from the probit models above.

Chapter 7

Membership Matters? Examinig the Effects of Membership on Compliance With Arms Control Agreements

Abstract

Among the myriad frameworks designed to control arms, there is considerable variation in their design—particularly in terms of their scope, membership, and flexibility. The causes and consequences of this variation, however, remain unexplained. In this chapter, I use the original "Arms Control Design Dataset" (ACDD) that tracks design characteristics of arms control regimes on an agreement-year and country-agreement-year basis to examine the effect of membership numbers—from bilateral to minilateral and multilateral frameworks—on compliance. In the process, I reflect on existing theoretical work concerning the effect of membership numbers on patterns of international cooperation in the context of arms control. Throughout, I point to a number of agreements that vary in terms of their membership before examining the Joint Comprehensive Plan of Action (JCPOA).

7.1 Introduction

The collapse of the INF Treaty and continued fears that there will be no extension and replacement of New START have led to a series of discussions of what a post-arms control world might look like.[1] As part of these discussions, global leaders—including U.S. President Trump and Russian President Putin have noted the possibility of multilateralizing existing arms limitation agreements via the inclusion of Beijing in the negotiations.[2] While existing

[1] Manzo, *Nuclear Arms Control Without a Treaty? Risks and Options After New START*.

[2] China, for its part, made clear through Chinese Foreign Ministry spokesman Lu Kang in a press conference on May 21, 2019 that China did not view Chinese inclusion in arms control favorably. China often points out that it has substantially lower numbers of nuclear warheads at its disposal when compared to the

arms control frameworks include both bilateral and multilateral endeavors, little work has been done to explain the causes of consequences of adding additional players to an arms control agreement—either related to their impact on bargaining or enforcement related to the regime. Interestingly, this debate mirrors anecdotal accounts of conversations in the context of the New START negotiations between the United States and Russia in 2009. Members of the U.S. negotiating team, in particular, weighed the benefits of providing an opportunity for participants beyond Moscow and Washington to observe the negotiation process with a view toward future participation in arms limitation and against the dangers of creating yet another issue for Moscow and Washington to negotiate over before the "real" negotiations were underway.[3]

The costs and benefits of designing a multilateral arms control agreement are reflected in recent challenges associated with the Joint Comprehensive Plan of Action (JCPOA) involving Iran and the P5+1 (China, France, Germany, Russia, the United Kingdom, and the United States) that serves as a central case study below. In brief, the U.S. decision to withdraw from the agreement, Iran's decision to re-start uranium enrichment beyond the 4 percent limits noted in the agreement, and the failure, at the time of this writing, of remaining states parties to the agreement to bring Iran back into compliance engage with a number of theoretical debates related to the effects of regime membership on compliance.

These developments raise the question, how should we consider the trade-offs associated with choosing bilateral or multilateral agreements? Thompson and Verdier, in their work investigating the determinants of regime design, offer a succinct account of these trade-offs as multilateral agreements fail to address the varying compliance costs associated with implementing the agreement while bilateral agreements are subject to increased transaction costs.[4] Multilateral agreements are also potentially subject to higher reputation costs,[5] more likely to have a professional staff or bureaucracy that report noncompliance,[6] and—with greater transparency—subject to increased domestic audience costs following leaders tying their hands by signing onto an agreement.[7]

The majority of work on questions of compliance as well as the causes and consequences of multilateralism have drawn on insights from environmental, trade, and human rights regimes.[8] Arms control has remained an under-studied phenomenon—despite a number of

United States and Russia.

[3]It is also worth noting that Tier 2 nuclear states have substantially smaller nuclear arsenals and, as a result, have a different force composition and deterrence strategy than the United States and Russia. Beijing's reliance upon land-based mobile missile systems, for example, decreases the likelihood that they would accept the verification and inspection requirements that are included in existing arms control treaty architectures.

[4]Alexander Thompson and Daniel Verdier, "Multilateralism, bilateralism, and regime design," *International Studies Quarterly* 58, no. 1 (2014): 15–28.

[5]Tomz, *Reputation and international cooperation: sovereign debt across three centuries.*

[6]Peter M Haas, "Compliance with EU directives: insights from international relations and comparative politics," *Journal of European Public Policy* 5, no. 1 (1998): 17–37.

[7]Slantchev, "Politicians, the media, and domestic audience costs."

[8]Thompson and Verdier, "Multilateralism, bilateralism, and regime design"; Chayes and Chayes, "Com-

cooperation theorists pointing to arms control in their theoretical work.[9]

Concerning the specific question addressed by this chapter, Williamson notes that "fostering compliance may be quite different in bilateral arms control than in multilateral arms control" but an examination of the causes and consequences of different membership patterns in arms control framework has yet to occur.[10] In this chapter, I examine the patterns of compliance outcome and assess whether they vary among bilateral, minilateral, and multilateral agreements.

Specifically, I consider how states have used arms control agreements to constrain their patterns of military technology development and deployment by posing the following research question:

- Are states parties more likely to comply with multilateral arms control agreements than bilateral arms control agreements?

In the chapter to follow, I present the finding that membership may not have as significant an effect on compliance outcomes as some of the more optimistic accounts of multilateralism suggest—at least in terms of compliance outcomes. I begin by examining the existing scholarly literature concerning institution membership and international cooperation and present a series of testable hypotheses related to existing theory. Then, I analyze a the membership characteristics of arms control agreements in the context of compliance using empirical data. Finally, I consider how the analysis reflects lessons learned concerning the bargaining and enforcement of the Joint Comprehensive Plan of Action discussed briefly above.

7.2 Multilateralism in Theory

The "institutional scope" of an agreement in terms of its membership represents a key characteristic that conditions both the creation and performance of various institutions.[11] In

pliance without enforcement: state behavior under regulatory treaties"; Mitchell, "Problem structure, institutional design, and the relative effectiveness of international environmental agreements"; Young, *International cooperation: Building regimes for natural resources and the environment*; Ovodenko and Keohane, "Institutional diffusion in international environmental affairs"; Joseph M Grieco, *Cooperation among nations: Europe, America, and non-tariff barriers to trade* (Cornell University Press, 1990); Jeffrey Kucik and Eric Reinhardt, "Does flexibility promote cooperation? An application to the global trade regime," *International Organization* 62, no. 3 (2008): 477–505; Helen V Milner and B Peter Rosendorff, "Democratic politics and international trade negotiations: Elections and divided government as constraints on trade liberalization," *Journal of Conflict resolution* 41, no. 1 (1997): 117–146.

[9]Abbott, "Trust but verify: The production of information in arms control treaties and other international agreements."

[10]Richard L Williamson Jr, "Hard law, Soft law, and Non-Law in multilateral arms control: some compliance hypotheses," *Chi. J. Int'l L.* 4 (2003): 59.

[11]Aggarwal, *Institutional designs for a complex world: Bargaining, linkages, and nesting*; Vinod K Aggarwal, *Liberal protectionism: The international politics of organized textile trade*, vol. 13 (Univ of California Press, 1985).

theory, the inclusion of large numbers of players may make bargaining in negotiations more difficult and "lowest common denominator" agreements more likely. On the other hand, reneging on commitments to larger numbers of players arguably becomes more difficult given the reputation costs of doing so.[12]

As noted above, various studies have considered the determinants of membership patterns in individual institutions or sets of institutions within various policy areas, including human rights treaties,[13] environmental treaties,[14] international courts,[15] alliance frameworks,[16] and economic agreements.[17] There are, however, fewer studies that engage with theory concerning the consequences of various types of membership—from bilateral to minilateral and multilateral agreements—on arms control. Addressing this gap in the literature is important given the contemporary salience of arms control agreements and the importance of engaging with security-related (and, at times, adversarial) cooperation.[18]

Below, I engage with realist and neo-liberal critiques of multilateralism that have contributed to the conventional wisdom that bilateral arms control agreements are easier to enforce before exploring some of the benefits of multilateralism outlined in the rationalist literature that point to the potential positive effects of multilateralism related to compliance outcomes.

7.2.1 Critiques of Multilateralism

As Kahler points out in his seminal article on multilateralism, realist perspectives on cooperation suggest that multilateral, cooperative frameworks are incompatible with the hierarchy of the international system and that powerful states are more likely to pursue their interests via bilateral bargaining "immune from the scrutiny of other states."[19] Instances of multilateral cooperation are subsequently explained on the basis of structural determinism—in which systemic factors drive the necessity for multilateral frameworks—to the benefit of powerful states—when it suits them.[20] This has been described in reference to international law as a powerful state's predilection to "pick and play" a role in those institutions that match a

[12]Tomz, *Reputation and international cooperation: sovereign debt across three centuries.*

[13]James Raymond Vreeland, "Political institutions and human rights: Why dictatorships enter into the United Nations Convention Against Torture," *International Organization* 62, no. 1 (2008): 65–101.

[14]Von Stein, "Do treaties constrain or screen? Selection bias and treaty compliance."

[15]Simmons, "Treaty compliance and violation."

[16]James D Morrow, "Alliances and asymmetry: An alternative to the capability aggregation model of alliances," *American journal of political science*, 1991, 904–933.

[17]Edward D Mansfield and Helen V Milner, *Votes, vetoes, and the political economy of international trade agreements* (Princeton University Press, 2012).

[18]A number of realist scholars, in particular, suggest that international cooperation occurs only at the margins and in issue areas in which relative gains concerns are minimal.

[19]Kahler, "Multilateralism with small and large numbers."

[20]Adrian Hyde-Price, "'Normative' power Europe: a realist critique," *Journal of European Public Policy* 13, no. 2 (2006): 217–234.

state's interests while eschewing other types of multilateral frameworks.[21]

Neo-liberal theory concerning membership in international institutions, on the other hand, points to the obstacles associated with cooperation in large groups.[22] Scholarship that followed explored "recognition and control problems" theorized to exacerbate bargaining problems—in which the ability of states parties to police compliance and apply sanctions for noncompliance are theorized to decrease in multilateral contexts.[23] The existing arms control literature reflects this theory leading to the conventional wisdom that "compliance is generally easier to enforce for bilateral than multilateral agreements."[24] This proposition yields a testable hypothesis for analysis:

- H_1: If an agreements includes more parties, then compliance is *less* likely.

Perhaps unsurprisingly, a number of scholars disagree with this perspective.

7.2.2 The Benefits of Multilateralism

Disagreeing with the critiques of multilateral frameworks, scholars of political economy have explored the substantive benefits associated with the consequences of establishing multilateral cooperative frameworks. In terms of normative characteristics, these include an abandonment of "bilateral and discriminatory arrangements that were believed to... increase international conflict."[25] Scholars have also argued that multilateral frameworks enhance democracy by "by restricting the power of special interest factions, protecting individual rights, and improving the quality of democratic deliberation."[26]

Rationalist scholars have also noted that states often use multilateral institutions to facilitate cooperation among partners with dissimilar—and even adversarial—preferences.[27] This logic concerning inter-state bargaining appears to apply to multilateral arms control, too, as states parties design frameworks that prescribe and proscribe specific types of behavior for different reasons. In the context of the NPT, for example, nuclear weapon states tend to privilege the non-proliferation aspects of the Treaty while non-nuclear weapon states focus

[21] Allan Gerson, "Multilateralism a la carte: the consequences of unilateral 'pick and pay' approaches," *European Journal of International Law* 11, no. 1 (2000): 61–65.

[22] Mancur Olson, *The Logic of Collective Action* (Harvard University Press, 1965).

[23] Michael Taylor, *The possibility of cooperation* (Cambridge University Press, 1987); Oye, "Explaining cooperation under anarchy: Hypotheses and strategies."

[24] Guthe et al., "Securing Compliance with Arms Control Agreements."

[25] Kahler, "Multilateralism with small and large numbers," 681. See also: Richard N Gardner, "Sterling-dollar diplomacy in current perspective," *International Affairs (Royal Institute of International Affairs 1944-)* 62, no. 1 (1985): 21–33.

[26] Robert O Keohane, Stephen Macedo, and Andrew Moravcsik, "Democracy-enhancing multilateralism," *International Organization* 63, no. 1 (2009): 1–31.

[27] Abbott and Snidal, "Hard and soft law in international governance"; Kenneth W Abbott et al., "The concept of legalization," *International Organization* 54, no. 3 (2000): 401–419; Koremenos, "Loosening the ties that bind: A learning model of agreement flexibility"; Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries."

on the disarmament provisions in Article VI.[28] Multilateral arms control agreements may also provide a series of compliance benefits related to a "naming and shaming" mechanism—most often discussed in the context of human rights provisions.[29] Disaggregated verification regimes that involve large numbers of state participants—typified by the CTBTO's 321 monitoring stations and 16 laboratories—and burden-sharing may also increase the likelihood of detecting non-compliance and bolstering the regime.[30]

Scholars—predominantly in discussions surrounding climate change negotiations—have also pointed the benefits of minilateral frameworks for addressing collective action problems by seeking "club benefits" associated with an increased likelihood of achieving an agreement by reducing the complexity of the negotiation process.[31] In the context of arms control, negotiations surrounding efforts to ban specific military technologies face similar obstacles to those faced in climate change negotiations—particularly concerning the bargaining of great powers and their outsized importance to achieving an accord. Like climate change, however, the optimal number of parties to include within a minilateral framework remains unclear. For those arms control agreements focused on nuclear weapons: Should all nuclear states be included? Should only those states that have abided by their NPT commitments be offered a seat at the table—omitting India, Pakistan, and Israel? Or should the "tier 1" nations—Russia and the United States—continue to lead on arms control efforts until their forces are more closely aligned with the rest of the P5 states?[32]

The theorized benefits of multilateralism also yield several testable hypotheses.

- H_{2a}: If an agreements includes more parties, then compliance is *more* likely.

An additional hypothesis might also explore the theorized benefits of minilateral institutions that derive the benefits of multilateral frameworks while having fewer collective action problems:

[28]Muller, "Compliance politics: A critical analysis of multilateral arms control treaty enforcement."

[29]Emilie M Hafner-Burton, "Sticks and stones: Naming and shaming the human rights enforcement problem," *International Organization* 62, no. 4 (2008): 689–716; Tomz, *Reputation and international cooperation: sovereign debt across three centuries*.

[30]Wolfgang Hoffmann, Rashad Kebeasy, and Petr Firbas, "Introduction to the verification regime of the Comprehensive Nuclear-Test-Ban Treaty," *Physics of the Earth and Planetary Interiors* 113, nos. 1-4 (1999): 5–9.

[31]Robyn Eckersley, "Moving forward in the climate negotiations: Multilateralism or minilateralism?," *Global Environmental Politics* 12, no. 2 (2012): 24–42; Robert Falkner, "A minilateral solution for global climate change? On bargaining efficiency, club benefits, and international legitimacy," *Perspectives on Politics* 14, no. 1 (2016): 87–101; Robert Gampfer, "Minilateralism or the UNFCCC? The political feasibility of climate clubs," *Global Environmental Politics* 16, no. 3 (2016): 62–88.

[32]In discussions with New START negotiators in Washington, DC, they noted that multilateralizing arms control faces substantial challenges given that China, France, and United Kingdom have each made clear that they would not consider participation in arms limitation agreements given the contemporary disparities in numbers between themselves and the United States and Russia. As a result, future bilateral reduction in Washington and Moscow are considered a precondition for minilateral negotiations.

- H_{2b}: If an agreements is minilateral (involving three to nine states parties), then compliance is *more* likely.

The analysis below also considers the null hypothesis in which:

- H_0: The number of parties included in an agreement has *no effect* on patterns of compliance.

7.3 Method

To examine these hypotheses, I provide a quantitative examination of the empirical record—comparing agreement outcomes across bilateral, minilateral, and multilateral contexts to yield the predicted probability of compliance in each agreement-year given the design choices concerning membership made by arms control negotiators and their respective governments.

7.3.1 Introducing the Arms Control Design Dataset

For the purposes of this chapter, I use a subset of nuclear arms control agreements that entered into force from Kreps's list of arms control agreements.[33]

As in the previous chapters, I leave out those agreements that have not entered into force and those that are institutions rather than agreements in this analysis. The primary justification for this decision is that states cannot be reasonably expected to comply with agreements that never entered into force—even if they made the decision to sign them.[34] Using this case-selection criteria, the dataset used in this chapter include 40 agreements composed of of 1,187 agreement-years.

Below, I introduce the variables coded within the Arms Control Design Dataset (ACDD).

7.3.2 Measuring Membership

I use two different criteria for coding membership of agreements. The first borrows from Vaynman's doctoral work that splits agreements into those that are bilateral (involving two states parties), minilateral (involving three to nine states parties), and large multilateral agreements (involving 10 parties or more).[35]

[33]Kreps, "The institutional design of arms control agreements" This list also reflects those compiled by the Nuclear Threat Initiative, Federation of American Scientists, and Goldblat's work.Goldblat, *Arms control: a survey and appraisal of multilateral agreements*; Goldblat, *Arms Control: The New Guide to Negotiations and Agreements*.

[34]Incidentally, both the United States and the Soviet Union both often abide by the limitations set out in various arms control agreements that did not enter into force.

[35]Vaynman, "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries." It is worth noting that the definition of minilateralism varies beyond the methodological choice made here. In some of the literature, it includes regimes and cooperative frameworks that include up to 30 states.

The second criterion draws a dichotomous distinction between those agreements that are bilateral and those are multilateral (involving three or more states parties). It is worth pointing out that as the dataset is composed of agreement-years, there are agreements that transition between the categories. START I, for example, negotiated between the United States and Soviet Union, was multilateralized by the Lisbon Protocol upon the dissolution of the USSR to address the 3,000 strategic nuclear weapons and 3,000 tactical nuclear weapons deployed within the newly independent states of Belarus, Kazakhstan, and Ukraine—increasing the number of states parties to the Treaty from two to five. COCOM, the Nuclear Suppliers Group, and Missile Technology Control Regime also steadily increased their respective numbers of states parties during the period covered by the dataset.

Among those frameworks included in the dataset, there is one case that does not fall simply into a coding criteria. I code the Mongolian Nuclear Weapons Free Zone—in which the Mongolian government unilaterally declared that the government would not pursue nuclear weapons technology—as a multilateral agreement in the dataset following the recognition of this status by the United Nations.[36]

These measures of independent variables investigating the type of membership within an arms control agreement is subsequently used in an analysis of compliance with each agreement.

7.3.3 The Dependent Variable: Measuring Compliance

Unlike treaty obligations that are spelled out in agreements, coding compliance involves taking into account allegations of breaches from historical, journalistic, and government records.[37] Where available, I use accounts in popular international presses and government documents to corroborate noncompliance on an agreement-year and country-agreement-year basis. In the most recent example, Russian deployment of the 9M729 on the Iskander launcher in 2008 represented a breach of the INF Treaty.[38] Russia, in response, argued that U.S. missile defense forces were also in breach of the Treaty. Compliance, for the purposes of this study, relates to a best estimation of states abiding by the letter of their agreements.[39]

For the purposes of this analysis, I use a range of three to nine states in order to compare my analysis and findings with previous work.

[36]This status is enshrined within UN documents: A/55/56 S/2000/160.

[37]The coding criteria for measuring compliance is discussed at greater length in Chapter 3. The coding criteria for the dependent variable is also consistent across the chapters—and is included in each for the benefit of the reader and to go alongside the discussion of measurement concerning each independent variable of interest.

[38]For a discussion of Russia's breach of the INF Treaty, see the Bureau of Arms Control and Verification's Compliance Report released in April 2016: Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments.

[39]Where possible, each episode of compliance is cross-referenced against chapter 9, "Compliance and Noncompliance," in Richard Burns' *Evolution of Arms Control.*Duffy, "Arms control treaty compliance"; Burns, *The evolution of arms control: from antiquity to the nuclear age.*

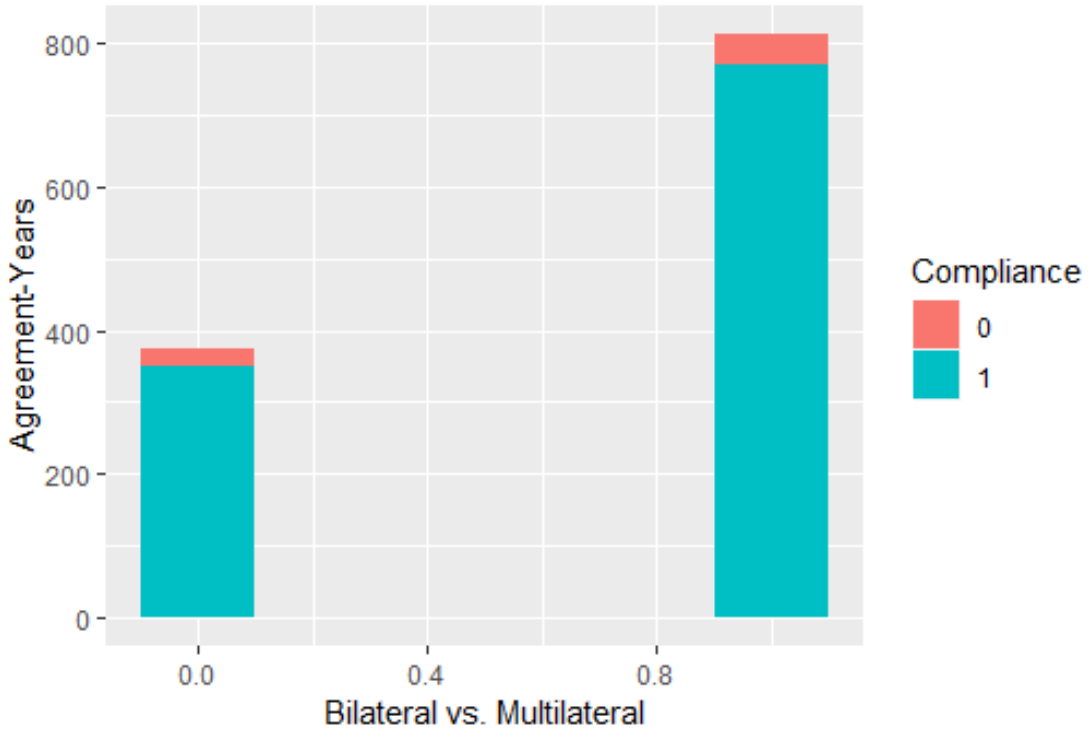

Figure 7.1: This figure provides a compliance count of agreement-years comparing bilateral and multilateral agreements. Compliance agreement-years are noted in green while non-compliance agreement-years are noted in red.

Within the dataset, there are a number of episodes of noncompliance from the 1980s onwards related to actions undertaken by Russia, the United States, North Korea, India, and Pakistan regarding their respective treaty commitments.

7.4 Quantitative Results

To assess the effects of membership scope on compliance, I perform a series of quantitative analyses using the empirical data described above.

7.4.1 Bilateralism, Minilateralism, and Multilateralism

In the first analysis (Models 1-3), I use a probit regression model to assess the effect of bilateral, minilateral, and large multilateral membership within arms control agreements on the predicted probability of compliance.[40] In this analysis, the membership type of interest

[40]A probit model uses a cumulative distribution function of the inverse standard normal distribution to define f (*)—rescaling the values of the dependent variable to fall between 0 and 1. Hence, whatever

is compared to all others in the dataset.[41]

$$\hat{Y} = f(\alpha + \beta x) \tag{7.1}$$

The results of this analysis are reported in Table 7.1. Interestingly, in terms of the theoretical disagreement concerning the effects of membership on international cooperation, none of these model specifications present statistically significant relationships between membership type and the predicted probability of compliance.[42]

Table 7.1: Probit models for the effect of arms control agreement type on treaty compliance on agreement-year basis

	(1) Model 1	(2) Model 2	(3) Model 3
Bilateral	-0.12 (0.12)		
Minilateral		-0.01 (0.21)	
Lg Multilateral			0.11 (0.12)
N	1187	1187	1187
Log-likelihood	-260.0	-260.5	-260.0
Constant	1.62 (0.07)	1.58 (0.06)	1.51 (0.09)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Among the models, Model 1—suggesting that bilateral agreements have a negative effect on the predicted probability of compliance—comes closest to a statistically significant and negative effect on compliance (*p-value* = 0.353). Examples of non-compliance involving bilateral treaties include the ABM Treaty, INF Treaty, CFE Treaty, and the Helsinki Accords.

Looking across models 1, 2, and 3, it appears that while there is no statistically significant effect of membership on compliance outcomes, there is an expectation that as an agreement becomes increasingly multilateral, it has a positive effect on compliance—as 7.3 makes clear.

In the section below, I use a dichotomous coding of multilateral membership to examine this effect further.

7.4.2 Bilateralism vs. Multilateralism

In Models 4-7 (summarized in Table 7.2), I use a dichotomous measure for bilateral and multilateral membership (in which bilateral = 0 and multilateral = 1) to re-run the analysis and include a series of control variables theorized to affect compliance.

$\alpha + \beta x$ equals, it can be transformed by the function to yield a predicted probability of compliance on an agreement-year basis. Alternative model specifications for are included in the Appendix.

[41] Bilateral agreement-years are compared to minilateral and large multilateral agreement-years. Minilateral agreement-years are compared to bilateral and multilateral agreement-years, and so on.

[42] These results are consistent with an analysis using alternative modeling approaches. In the Appendix to this chapter, I include a parallel analysis using logistic regression rather than the probit model described here.

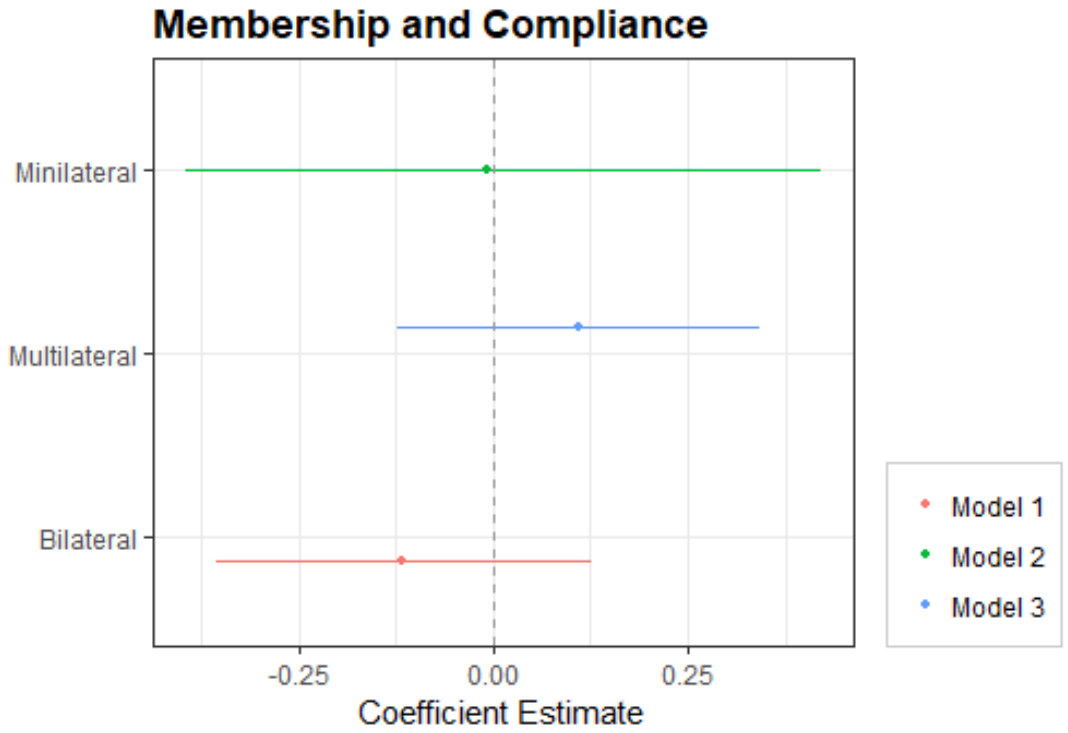

Figure 7.2: This figure shows the coefficient estimates with 95 percent confidence intervals reported in Table 7.1 in graph form.

Table 7.2: Probit models for the effect of arms control agreement type using a categorical variable on treaty compliance on agreement-year basis

	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
Multilateral	0.12 (0.12)	0.46 (0.17)***	0.20 (0.13)	0.43 (0.17)**
Stringency		0.17 (0.07)***		0.18 (0.07)***
Agreement Type		-0.46 (0.07)***		-0.46 (0.07)***
Sunset		0.65 (0.27)**		0.72 (0.32)**
Successor			0.42 (0.25)*	-0.20 (0.31)
Cold War			0.35 (0.25)**	0.31 (0.16)*
N	1187	1187	1187	1187
Log-likelihood	-260	-227.6	-256.0	-225.1
Constant	1.50 (0.10)	2.25 (0.19)	1.34 (0.11)	2.22 (0.20)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In line with the first analysis, there is once again no statistically significant relationship between multilateral agreements and compliance. As expected, given the results from Models

1-3, Model 4 reports a positive correlation between multilateral agreements and the predicted probability of compliance. As control variables are added to the analysis, this positive correlation becomes statistically significant.

In Model 5, I include a series of design variables used in the previous chapters theorized to affect compliance—including two categorical variables that assess the stringency of the verification regime and the type of agreement along with a binary variable used to measure the inclusion of a termination clause within the agreement. In line with the findings reported in the prior chapters, termination clauses are positively correlated with the predicted probability of compliance while agreements that address more complex challenges related to arms limitations and arms bans have a negative effect on the predicted probability of compliance.

In Model 6, I include two additional control variables related to the context in which an arms control agreement is reached. First, I include a binary successor variable to consider whether the agreement that follows a prior agreement regulating the same military technology with a similar design has an effect on compliance. The logic for including this control is that agreements modeled on past agreements that have already been negotiated and complied with are more likely to be complied with in the future—this might be described as a "practice makes perfect" logic. As expected, the successor variable is positively correlated with compliance.

Second, I include a variable that categorizes each agreement-year in the dataset on the basis of occurring during the Cold War—with 1991 as the cut-off point. Beyond being a fairly normal control for social science analyses of this type, there are a number of theories that suggest that its inclusion might impact the result. On the one hand, the Cold War—and the intense strategic rivalry between the United States and USSR that it embodies—may contribute to non-compliance given the incentives to cheat on agreements in pursuit of a competitive advantage. On the other hand, the stabilizing features of Cold War competition and dynamics of mutually assured destruction related to nuclear forces may contribute to compliance. In Models 6 and 7, I find support for the latter hypothesis.

Taken together, these models provide limited support for the proposition that multilateral frameworks have a higher predicted probability of compliance relative to their bilateral counterparts. With that said, this correlation does not amount to a statistically significant relationship and subsequently does not rule out the null hypothesis, H_0. Incorporating examples of non-strategic arms control and continuing to track patterns of membership and compliance in venues of broader international cooperation, it may be possible to characterize the performance of membership design on treaty outcomes.

The predicted probability of compliance in any agreement-year can also be calculated using the coefficients of Models 4-7 noted in Table 7.2 to examine the effect of membership on compliance.

For example, for Model 5:

$$\hat{Compliance} = F(2.25 + 0.46(\texttt{Multi}) + 0.17(\texttt{String}) - 0.46(\texttt{AgType}) + 0.65(\texttt{Sunset})) \quad (7.2)$$

where F is the cumulative distribution function of the inverse standard normal distribution and 1 is the value of Y associated with compliance.

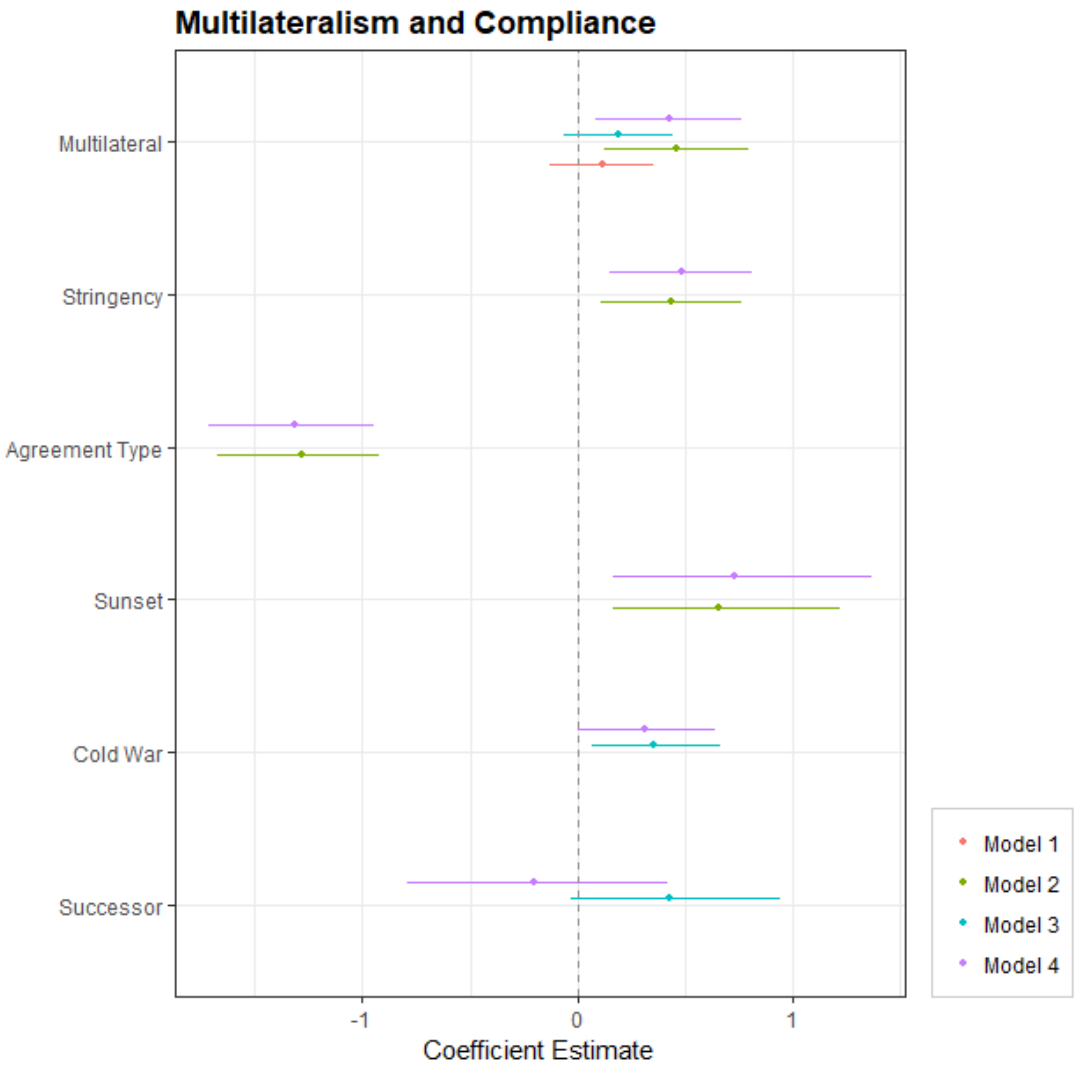

Figure 7.3: This figure shows the coefficient estimates with 95 percent confidence intervals reported in Table 7.2 in graph form.

This equation allows us to calculate the predicted probability of compliance for each type of agreement on an agreement-year basis holding each of the co-variates at their mean value.[43] The results of this analysis are reported in Table 7.3.

Table 7.3: This table notes the variation in the predicted probability of compliance ($Y = 1$ for a given agreement-year on the basis of the treaty being bilateral or multilateral using Models 4-7 and holding all control variables at their mean value.

Model	**Bilateral**	**Multilateral**
Model 4	93.3 %	94.7 %
Model 5	92.8 %	97.3 %
Model 6	92.9 %	95.2 %
Model 7	93.3 %	97.3 %

While multilateral agreements increase the predicted probability of compliance, it is important to bear in mind that these calculations of predicted probability do not take statistical significance into account. To further consider the effect of verification on compliance, it is worth considering empirical examples of non-compliance within bilateral and multilateral contexts. This empirical record is considered below following the sensitivity analysis of the statistical results noted above.

7.5 Sensitivity Analysis

In this section, I perform a series of sensitivity analyses related to the model specifications above.

7.5.1 Multicollinearity

First, I test the multicollinearity of the standard probit model used in the analysis above. To do this, I use a variance inflation factor (VIF) to measure how easily it is to achieve the same model outcomes from a linear regression using the other predictors using Model 7 (that includes both the independent variable of interest, membership, alongside design co-variates and control variables. The square root of the VIF tells you how much larger the standard error of the estimated coefficient is in respect to a case when that predictor is independent of the other predictors.

A general guideline is that a VIF larger than 5 or 10 indicates that the model has problems estimating the coefficient..[44] Table 7.4 below shows the VIF for Model 7 described above.

[43]The equation can also be used to calculate the likelihood of compliance given a variety of design characteristics.

[44]Thompson et al., "Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results."

Table 7.4: This table shows the Variance Inflection Factor for the probit model including all four design variables and the Cold War and Successor control variables used in Model 7.

Variables	*Multilateral*	*Stringency*	*Agreement Type*	*Sunset*	*Cold War*	*Successor*
VIF	1.51	1.87	1.74	1.50	1.03	1.57

Model 7 is used to predict the effect of the agreement membership (comparing bilateral and multilateral agreements) on the predicted probability of compliance on an agreement-year basis with institutional design co-variates. In this case, the co-variates are the categorical agreement type variable, a categorical variable describing the verification regime, and a dummy variable denoting whether the agreeent has a termination clause.

The results of this analysis suggest that multicollinearity, in which the explanatory variables are highly correlated, is not a concern for the models above.

7.5.2 Independence and Heteroskedasticity Probit Results

The existing methodological literature suggests that models using panel data may internalize substantial cross-sectional dependence in the errors. This may occur due to the presence of shocks common to the data points, unobservables that ultimately become part of the error term, or temporal dependence. To address concerns surrounding the independence of both the outcome variables and the regressors, I run a series of regression models with clustered standard errors that adjust for non-independence across agreements and across years.

To do this, I assess whether circumstances in which the variability of a variable is unequal across the range of values of a second variable that predicts it exist in the underlying data used in the probit models above. This test is particularly important given that heteroskedasticity in these models can represent a major violation of the probit (and logit) model specifications, which assume homoskedastic errors.

For any non-linear model (including the logit and probit models used throughout this dissertation), however, heteroscedasticity has more severe consequences: the maximum likelihood estimates of the parameters will be biased (in an unknown direction), as well as inconsistent. If this is the case, the likelihood function needs to be modified to take the heteroskedasticity into account).

Below, I use a heteroskedastic probit model to re-assess the effect of membership on patterns of compliance on an agreement-year basis using Huber-White robust clustered standard errors.[45]

In the table, I am particularly concerned with whether there are differences in the direction of the effect, statistical significance, and departures from the standard errors reported in Table 7.2.

[45]I use the *sandwich* R package to carry out this analysis.Zeileis, "Object-oriented computation of sandwich estimators"; White et al., "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity."

Table 7.5: Heteroskedastic probit models for the effect of membership type on treaty compliance on agreement-year basis

	(4) Model 4HP	(5) Model 5HP	(6) Model 6HP	(7) Model 7HP
Multilateral	0.10 (0.13)	0.44 (0.17)***	0.19 (0.13)	0.42 (0.16)**
Stringency		0.18 (0.07)***		0.20 (0.07)***
Agreement Type		-0.48 (0.06)***		-0.46 (0.07)***
Sunset		0.83 (0.34)**		0.86 (0.52)*
Successor			0.55 (0.26)**	-0.11 (0.43)
Cold War			0.36 (0.15)**	0.31 (0.17)*
N	1187	1187	1187	1187
Log-likelihood	-257.4	-222.7	-252.7	-220.6
Constant	1.52 (0.10)	2.29 (0.14)	1.34 (0.11)	2.23 (0.09)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As is the case in the previous chapters, this alternative modeling specification does not dispute the results above. Once again, multilateralism appears to have a positive effect on the predicted probability of compliance though without statistical significance.

7.5.3 Time Dependence

I now turn to the question of whether the findings outlined above are driven by temporal dependence.

To address this, I use Carter and Signorino's cubic polynomial approximation method described in Chapter 3 to include t, t^2, and t^3 in several regression models described above. In these models t represents the time since the last "event."[46] In this analysis, the specific event at issue is a breach of an arms control agreement. Thus, t represents the time, in years, since the last episode of non-compliance on an agreement-year basis.

I report two models including t, t^2, and t^3. The first model presents the independent variable of interest while the second includes the independent variable of interest alongside the additional design characteristics and control variables.

Table 7.6: Cubic polynomial approximation probit models for the effect membership on treaty compliance on agreement-year basis

[46] Carter and Signorino, "Back to the future: Modeling time dependence in binary data."

	(4) Model 4	(4) Model 4CP	(7) Model 7	(7) Model 7CP
Multilateral	0.12 (0.12)	0.10 (0.25)	0.43 (0.17)**	0.28 (0.24)
Agreement Type			-0.47 (0.07)***	-0.40 (0.10)***
Stringency			0.19 (0.07)***	0.21 (0.09)**
Sunset			0.73 (0.32)**	0.65 (0.42)
Successor			-0.20 (0.31)	0.60 (0.45)
Cold War			0.31 (0.16)*	0.72 (0.22)***
t		1.12 (0.15)***		1.00 (0.14)***
t^2		-0.09 (0.02)***		-0.08 (0.01)***
t^3		0.002 (0.0004)***		0.002 (0.0004)***
N	1187	1187	1187	1187
Log-likelihood	-260.0	-130.8	-225.1	-109.1
Constant	1.50 (0.10)	-1.08 (0.25)	2.22 (0.20)	-0.59 (0.39)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As is the case in the standard probit model analysis, the effect and statistical significance of membership varies—with and without taking into account temporal dependence. Perhaps most important is that the p-value associated with the membership variable in Model 7CP is substantially larger ($p = 0.06$) than in Model 7 ($p = 0.02$). As has been the case throughout the analysis of temporal dependence concerning arms control outcomes, compliance outcomes in on period appear to be influenced by compliance outcomes in past periods. This, however, has only a marginal effect on the results reported in this chapter.

7.5.4 Selection Effects

As discussed in Chapter 3 and as Downs et al. and von Stein have noted, when an independent variable is itself a strategic choice on an outcome there are significant selection effects that must be taken into account when analyzing observational data.[47] In simplest terms, any outcome variables (in this case, compliance) must be measured against the predilection of a state taking the same action in the absence of the variable of interest(in this case an arms control agreement). As both the choice of a state to undertake an arms control agreement of a specific *design* and the decision to comply with an agreement on an agreement-year basis, the research in question .

In this agreement-year-based analysis of the ACDD, the analysis does not consider that the "enforce-ability" of the agreement as well as the underlying probability of compliance for states parties varies and that this variation affects both the choice of which states should be included in an arms control regime as well as compliance outcomes.

The the findings presented in this chapter like those presented throughout have the caveat, common among observational studies, that they provide a first cut at the causal relationship

[47]Downs, Rocke, and Barsoom, "Is the good news about compliance good news about cooperation?"; Von Stein, "Do treaties constrain or screen? Selection bias and treaty compliance."

between institutional design characteristics and compliance outcomes on an agreement-year basis.

7.6 The Empirical Record

As noted above, the empirical record provides examples of both bilateral and multilateral frameworks resulting in non-compliance.

7.6.1 Bilateral Non-Compliance

In the bilateral case, the reciprocal benefits of participating in and complying with arms control obligations represent the most immediate driver of state behavior. In discussions with prior arms control negotiators concerning Russia's abrogation of INF, they point out that arms control requires practice—and that the termination of the verification regime in 2001 combined with the cessation of regular meetings of the Special Verification Commission—likely increased the likelihood of Russian abrogation of the Treaty due to a decrease in the perceived costs of abrogating the Treaty.[48] In the same discussion, past negotiators suggested that compliance is best explained by the reciprocal and relative benefits provided by an arms control regime—whether in the form of information exchange or in terms of allowing a reduction of arms numbers and a decrease in information asymmetries between states parties that ultimately strengthen the strategic position of the signatories.

7.6.2 Multilateral Non-Compliance

The IAEA, representing the first multilateral verification organization tasked with monitoring nuclear safeguards agreements, has investigated eight cases of non-compliance.[49] In the cases of Romania, South Korea, and Egypt, a single public noncompliance report led the governments of those three states to policy remedies. In five cases involving Libya, Syria, Iraq, North Korea, and Iran, compliance issues were more complicated. Each of these cases are fairly unique, with the IAEA establishing its own series of procedures and norms associated with inspections and compliance reporting.[50] Findlay, examining the institutional role of the Director-General and Board of Governors describes each case as "unique, dynamic, and nonlinear" as well as noting that its 1957 Statute was "charmingly naive" in its expectation that states would quickly take steps to address noncompliance concerns noted by

[48]Interview in Washington, DC in March 2019.

[49]These cases have been outlined in a series reports of both the UN Security Council and the IAEA Board of Governors.

[50]Indeed, the IAEA has in some cases provided guidance to the UN Security Council regarding the appropriateness of responding to noncompliance. In both the Romanian and Libyan cases, the IAEA provided noncompliance reports 'for information purposes' with the UNSC deciding not to take the cases to a vote. Trevor Findlay, "IAEA Noncompliance Reporting And the Iran Case," *Arms Control Today* 46, no. 1 (2016): 30.

the IAEA.[51] The episodes of non-compliance related to safeguards reported to the UNSC also provide a window into the decision-making of members of the UN Security Council concerning noncompliance resolutions. Upon the referral of the Iraqi (1991) and North Korean (1993) noncompliance cases to the UN Security Council, the vast majority of states supported a resolution recognizing non-compliance. In more recent cases involving Iran (2005) and Syria (2011), the majorities have become smaller, with an increasing number of states abstaining from voting. In all eight cases, the public acknowledgement of non-compliance via reporting by the IAEA and voting in the United Nations—presents a mechanism for punishing non-compliant behavior—with mixed results. These reporting mechanisms reflect the reputation-oriented theories outlined above.[52] These cases also serve as an example of an agreement involving an international verification organization that has a professional staff or bureaucracy that publicly reports noncompliance.[53] This process differs considerably from U.S. annual reports concerning compliance mandated by Congress and managed by the Department of State and the occasional Russian speeches and documents that used to monitor compliance and non-compliance.

As mentioned in the introduction to this chapter, contemporary efforts to address U.S. withdrawal and Iranian non-compliance with the Joint Comprehensive Plan of Action signed in July 2015 and implemented in January 2016 provides a recent, compelling example of the difficulties associated with multilateral—and in this case minilateral—arms control frameworks.

The JCPOA includes various measures designed to limit the enrichment of uranium to below 3.67 percent until 2030 as well as limiting the number (6,104) and specifying the type and location of centrifuges in Iran. The IAEA was given responsibility for monitoring and verifying Tehran's compliance with the agreement. The agreement also terminated UN sanctions in January 2016 with some U.S. and EU sanctions lifted following its signing with full termination of sanctions due to follow in 2023. At the time of its signing the Agreement was described by its supporters as the best possible deal to arrest Iran's nuclear program.[54]

Since implementation, however, the United States has announced its withdrawal from the Agreement and the re-imposition of sanctions despite the other members of the P5+1 calling for the United States to abide by the terms of the Agreement. Efforts by European states, in particular, have failed to bring the United States and Iran back to the table. At the time of writing in July 2019, Iran has responded by enriching uranium beyond the 3.67 percent threshold while calling on European states to do more to soften the impact of U.S. sanctions. The IAEA has yet to announce Iranian non-compliance with the provisions of the JCPOA though Iranian public statements suggests that further enrichment is likely.

While the JCPOA remains something of a moving target for analysts and scholars given its uncertain future, it makes salient the difficulties associated with addressing compliance

[51]Findlay, "IAEA Noncompliance Reporting And the Iran Case."

[52]Tomz, *Reputation and international cooperation: sovereign debt across three centuries.*

[53]Haas, "Compliance with EU directives: insights from international relations and comparative politics."

[54]Nephew, "Triggers, Redlines, and the Fate of the Iran Nuclear Accord."

issues in a multilateral context—particularly when it remains unclear what the appropriate venue is for addressing the non-nuclear aspects of the agreement pertaining to sanctions.

7.7 Conclusion

As noted above, a quantitative analysis of the empirical record of nuclear arms control agreements finds limited support for the hypothesis that multilateral agreements contribute to compliance outcomes—hinted at by the positive but statistically insignificant correlation between multilateralism and compliance. With regard to the existing theory concerning the relative benefits of bilateral and multilateral treaty design vis à vis compliance, this analysis suggests that the jury remains out and that more work is needed to provide empirical support for the proposition that multilateral membership is more desirable than bilateral membership in relation to compliance outcomes.

Indeed, there have been increasing calls for existing arms control processes to multilateralized—with new efforts by the United States to include China in nuclear arms limitation agreements. In terms of nuclear forces, however, the two-tiered nature of the contemporary context in which U.S. and Russian forces are substantially larger than all others serves as a primary obstacle to multilateral cooperation.[55] The nuclear force postures and deterrence strategies of the three remaining members of the P5 are substantially different from the United States and Russia—not least in terms of warhead numbers.[56] Given the divergence in nuclear posture and strategy between the two tiers of nuclear states, it is worth considering whether arms control frameworks that privilege robust inspection and verification regimes are likely to be appropriate in multilateral contexts. Would Beijing, for example, acquiesce to inspections of their mobile missile systems in which the location of the system is intrinsically linked to the survivability of the force and its deterrence mission? Including additional parties to these agreements may, as pointed out in the theory section above, complicate inter-state bargaining—which in the context of contemporary arms control already takes months to years rather than days to weeks.

With that said, the inclusion of second tier nuclear powers in negotiations surrounding the extension of arms control beyond 2021 may offer enforcement benefits as well as providing an opportunity for institutional learning for those states that are new to the arms control architecture by socializing them to the process—as well as the fact that arms control provides a strategic rather than normative benefit. This, according to a number of individuals involved in the New START negotiations, represented one of the c most compelling arguments for including China in future arms limitation talks.

[55]Hans M Kristensen and Robert S Norris, "Global nuclear weapons inventories, 1945–2013," *Bulletin of the Atomic Scientists* 69, no. 5 (2013): 75–81.

[56]The United States and Russia have approximately 1,400 warheads each under New START limits while the Nuclear Notebook estimates for the rest of the P5 place their warhead numbers at approximately 300 each.Kristensen, "Global Nuclear Arsenals, 1990–2018"; Bruce Larkin, *Nuclear Designs: Great Britain, France and China in the global governance of nuclear arms* (Routledge, 2018).

There may also benefits to be drawn from focusing on minilateral frameworks that may be easier to achieve than their broader, multilateral counterparts. With that said, multilateral membership—based on the empirical record—does not offer a panacea.

Beyond the nuclear forces that were the focus of this chapter, there may be lessons to be drawn from the analysis for non-nuclear arms control negotiations and agreement design. The most obvious example of contemporary arms control negotiations that might consider the consequences of regime membership concerns the regime to address and cyber weapons amid efforts to regulate the use of cyberspace in inter-state conflict. Both Beijing and Moscow have, perhaps mischievously, proposed intergovernmental, multilateral processes to establish global norms of behavior involving several international institutions including the International Telecommunication Union, a UN Group of Governmental Experts, and UN General Assembly open-ended working group.[57] The United States, on the other hand, appears to have preferred a bilateral approach to establishing the inappropriateness of specific behaviors in cyberspace—namely the targeting of critical infrastructure by Chinese actors.[58] The United States has also latterly sponsored a UN resolution to create a new UN Group of Governmental Experts to identify and promote compliance with cyber "norms of behavior." Within each of the forums set up to discuss military applications of Internet technology, observers in Geneva (the location of several GGEs under the auspices of the Conference on Disarmament (CD)) have noted that the composition of those around the table have shaped the discussion—including disagreements related to the very definitions of what constitutes cybersecurity.

As scholars grapple with the consequences of membership within international institutions in general and arms control negotiations in particular, more empirical data is needed to assess the historical effects of membership on treaty outcomes. Future work might also reflect on how and why arms control may offer a peculiar example of international cooperation in which the existing theories emanating from non-security domains concerning the consequences of multilateralism may not apply.

Appendix

The choice to use probit or logit models is generally considered to be one of personal preference when dealing with dichotomous outcome variables. As a reminder, OLS regressions are inappropriate as the errors from a linear probability model with dichotomous outcome variables violate homoskedasticity and normality of errors assumptions, resulting in invalid standard errors. As mentioned in Chapter 3, there is increasingly disagreement about whether these drawbacks inherent within OLS methods necessitate the use of probit or logit estimators.

Below, I carry out an identical analysis to those carried out using probit regression methods using logistic regression. The number associated with each model remains the

[57]Meyer, "Cyber-security through arms control: an approach to international co-operation."

[58]Grigsby, "The end of cyber norms."

same with those using a logistic regression denoting an L. For example, Model 1 above can be compared to Model 1L, below.

Table 7.7: Logit models for the effect of arms control agreement type on treaty compliance on agreement-year basis

	(1) Model 1L	(2) Model 2L	(3) Model 3L
Bilateral	-0.25 (0.26)		
Minilateral		-0.02 (0.44)	
Lg Multilateral			0.24 (0.25)
N	1187	1187	1187
Log-likelihood	-260.0	-260.5	-260.0
Constant	2.89 (0.16)	2.80 (0.13)	2.67 (0.19)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7.8: Logit models for the effect of arms control agreement type using a categorical variable on treaty compliance on agreement-year basis

	(4) Model 4L	(5) Model 5L	(6) Model 6L	(7) Model 7L
Multilateral	0.25 (0.26)	1.02 (0.34)***	0.39 (0.27)	1.00 (0.34)***
Stringency		0.36 (0.13)***		0.36 (0.13)***
Agreement Type		-0.94 (0.14)***		-0.95 (0.14)***
Sunset		1.51 (0.63)**		1.73 (0.76)**
Successor			0.90 (0.55)	-0.48 (0.69)
Cold War			0.76 (0.34)**	0.64 (0.35)*
N	1187	1187	1187	1187
Log-likelihood	-260.0	-226.8	-256.1	-224.4
Constant	2.64 (0.21)	4.18 (0.42)	2.31 (0.23)	4.10 (0.46)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As is the case in each of the quantitative chapters, the conclusions drawn from the probit analysis are not substantially different from those using a logistic regression model with no changes in the direction of the effects for each of the institutional design co-variates. The most notable change is that, in line with other models throughout the dissertation, the successor characteristic is no longer statistically significant in Model 6L.

Chapter 8

Design Matters: The Institutional Design of the JCPOA and TPNW

Abstract

This chapter briefly examines the consequences of the quantitative analysis carried out in the prior chapters by applying the ACDD to contemporary debates surrounding the Joint Comprehensive Plan of Action and the Treaty on the Prohibition of Nuclear Weapons. In the chapter, I use the ACDD as training data to calculate the predicted probability of compliance for each arms control agreement on the basis of their respective design characteristics.

8.1 Introduction

Discussions concerning the appropriateness or inappropriateness of arms control agreement design too often occur in a vacuum and, as past negotiators have pointed out, are often driven by heuristics rather than empirics. But, what if the empirical record offered clues about what the consequences of arms control design might be? This chapter uses the lessons learned from the analysis carried out in the previous quantitative chapters via an exploration of two arms control agreements of contemporary importance: the Joint Comprehensive Plan of Action (JCPOA) addressing Iranian nuclear proliferation and the Treaty on the Prohibition of Nuclear Weapons (TPNW, also known as the "Ban Treaty").

Below, I discuss the process of using the ACDD as training data before discussing the background and design of each arms control regime. In the final section, I note the potential of building out this dataset further to allow for an increasingly granular analysis of those design considerations that drive outcomes of interest to both academic researchers and policy-makers.

8.2 The ACDD as Training Data

As mentioned above, the ACDD allows for an empirically grounded analysis of the consequences associated with the institutional design of arms control agreements. With that said, arms control agreements are not always borne from a utilitarian calculus of expected costs and benefits. As analysts critique the design of arms control regimes during and following the completion of negotiations, however, this work allows for a probabilistic, empirically-informed discussion of institutional design using the empirical record as a guide.

Recalling that the quantitative chapters of this dissertation calculate the predicted probabilities of compliance outcomes on the basis of institutional design characteristics produced by a probit regression model calculated with empirical data in the Arms Control Design Dataset, I use these same equations to assess each of the three arms control agreements that are the focus of this chapter.

Below, I use the coefficients from a regression equation involving the all of the institutional design parameters of theoretical interest that are the subject of this dissertation to calculate the predicted probability of compliance in a given agreement-year for each of the arms control regimes discussed in this chapter.[1]

$$\hat{Compliance} = F(2.25 - 0.46(\texttt{AgType}) + 0.17(\texttt{String}) + 0.65(\texttt{Sunset}) + 0.46(\texttt{Multi})) \quad (8.1)$$

With this equation, I compare the predicted probabilities of compliance across each type of agreement by coding each agreement's design characteristics and using them to predict the probability of compliance on an agreement-year basis. It is important to note that this predicted probability of compliance with an arms control agreement on an agreement-year basis is quite different from predicting non-compliance outright. Below, I begin by considering the design characteristics of the JCPOA.

8.3 Joint Comprehensive Plan of Action

As discussed briefly in Chapter 7, efforts to address Iran's nuclear weapons program over three decades culminated in the negotiation and entry into force of the Joint Comprehensive Plan of Action in 2015. During this period, numerous scholarly works have sought to understand Iran's interest in nuclear proliferation.[2] In the section to follow, I outline the design of the JCPOA before assessing its design in light of the analysis carried out in this dissertation thus far.

Iran and the P5+1 (China France, Germany, Russia, the United Kingdom, and the United States) signed the the Joint Comprehensive Plan of Action (JCPOA), colloquially

[1] The coefficient estimates for this equation are calculated in Model 5 described in Chapter 7.

[2] For a summary of existing quantitative work examining the causes of nuclear proliferation, see: Gartzke and Kroenig, "Social Scientific Analysis of Nuclear Weapons: Past Scholarly Successes, Contemporary Challenges, and Future Research Opportunities"; Erik Gartzke and Matthew Kroenig, "Nukes with numbers: empirical research on the consequences of nuclear weapons for international conflict," *Annual Review of Political Science* 19 (2016): 397–412.

described as "the Iran Deal," on July 14, 2015. The agreement was subsequently endorsed by UN Security Council Resolution 2231 and adopted on July 20, 2015. During the negotiations between the states parties and upon signing, there was considerable debate concerning whether the agreement was fit for purpose.[3] On the one hand, scholars and past negotiators suggested that the agreement represented and represents the best possible compromise that uses sanctions relief to elicit a promise from Tehran to eschew the development of nuclear weapons.[4] On the other, some doubted—and continue to doubt—the ability of the agreement to arrest Iran's nuclear program and indict the agreement for failing to address broader geopolitical considerations in the region as well as not addressing Iranian nuclear proliferation in perpetuity.[5]

Setting aside these debates, I turn to the institutional design of the JCPOA itself, before examining how these design consideration may affect compliance outcomes.

8.3.1 Agreement Type

The first question for the purposes of this analysis are what the agreement sets out to do. Is it focused on nuclear risk reduction using domestic law, banning nuclear tests, limiting the number of nuclear arms (warheads or delivery vehicles) or prohibiting the development of nuclear weapons altogether?

To make this determination, I draw on the Treaty text itself to note that the JCPOA serves as an example of an effort to *prohibit* the development and deployment of nuclear weapons. As the Preface of the Agreement notes, the JCPOA "will ensure that Irans nuclear programme will be exclusively peaceful... [And] consistent with international non-proliferation norms."[6] In the Preamble, the Agreement also notes, "Iran reaffirms that under no circumstances will Iran ever seek, develop or acquire any nuclear weapons."[7]

For the purposes of my analysis, the JCPOA's *agreement type* score described in greater detail in Chapter 4 is a 4, as noted in Table 8.1.

[3]Fuhrmann explores this debate in: Matthew Fuhrmann, "When Preventive War Threats Work for Nuclear Nonproliferation," *The Washington Quarterly* 41, no. 3 (2018): 111–135.

[4]Mark Fitzpatrick, "Iran: A good deal," *Survival* 57, no. 5 (2015): 47–52; Nephew, "Triggers, Redlines, and the Fate of the Iran Nuclear Accord"; Henry Kissinger and George P Shultz, "The Iran deal and its consequences," *Wall Street Journal*, 2015,

[5]Concerns surrounding breakout of from the straitjacket imposed by the agreement are driven, in part, by technical rather than institutional considerations. Because the JCPOA allows for enrichment of uranium throughout the deal and because there is a gradual plateau in the amount energy required to enrich uranium used in energy programs (LEU) to weapons-grade (HEU), a number of scholars and policy-makers have argued that the agreement fails to go far enough. For more on the dissent related to the JCPOA, see: Bruno Tertrais, "Iran: An experiment in strategic risk-taking," *Survival* 57, no. 5 (2015): 67–73; Matthew Kroenig, "The return to the pressure track: The trump administration and the Iran nuclear deal," *Diplomacy & Statecraft* 29, no. 1 (2018): 94–104.

[6]Preface, Joint Comprehensive Plan of Action.

[7]Preamble, par. iii, Joint Comprehensive Plan of Action.

8.3.2 Verification Regime

I turn now to the verification regime included within the JCPOA and use the categorical *stringency* variable that is the subject of Chapter 5 to score the Agreement.

As noted in the Treaty text, "The International Atomic Energy Agency (IAEA) will be requested to monitor and verify the voluntary nuclear-related measures as detailed in this JCPOA. The IAEA will be requested to provide regular updates to the Board of Governors, and as provided for in this JCPOA, to the UN Security Council." [8] The Agreement goes on to note that:

> Iran will allow the IAEA to monitor the implementation of the voluntary measures for their respective durations, as well as to implement transparency measures, as set out in this JCPOA and its Annexes. These measures include: a long-term IAEA presence in Iran; IAEA monitoring of uranium ore concentrate produced by Iran from all uranium ore concentrate plants for 25 years; containment and surveillance of centrifuge rotors and bellows for 20 years; use of IAEA approved and certified modern technologies including on-line enrichment measurement and electronic seals; and a reliable mechanism to ensure speedy resolution of IAEA access concerns for 15 years, as defined in Annex I.[9]

This monitoring and verification role involves continuous monitoring of uranium mines and centrifuge production facilities among other sites. But while Iran commits to provisionally apply the Additional Protocol, it falls short of applying an "anytime, anywhere" standard provided by other arms control regimes. As a result, the JCPOA is scored as a 2 on the ACDD's *stringency* scale.[10]

8.3.3 Termination

In terms of the termination of the agreement, most of the JCPOA's provisions concerning the limitation of nuclear activities have a 15-year term ending in 2030 with the Joint Commission slated to continue to meet quarterly for a period of 25 years.

As the JCPOA notes, "Based on its long-term plan, for 15 years, Iran will carry out its uranium enrichment-related activities, including safeguarded research and development exclusively in the Natanz Enrichment facility, keep its level of uranium enrichment at up to 3.67 percent, and, at Fordow, refrain from any uranium enrichment and uranium enrichment research and development and from keeping any nuclear material."[11] Like other agreements noted in Chapter 6 examining the use of sunset mechanisms in arms control, the inclusion

[8] Preamble, par. x, Joint Comprehensive Plan of Action.

[9] Section C, par. 15, Joint Comprehensive Plan of Action.

[10] As a reminder, the stringency measure is a categorical four-point scale that runs from 0 (no verification regime) to 3 (challenge inspection regime) to assess the types of verification being carried out during treaty monitoring.

[11] Section A, par. 5, Joint Comprehensive Plan of Action.

Table 8.1: This table describes the institutional design characteristics of the JCPOA

Institutional Design	Description	Score
Agreement Type	Iran will not "seek, develop or acquire any nuclear weapons"	4
Verification Regime	Continuous on-site monitoring and inspection by IAEA inspectors	2
Termination Clause	Various provisions of the JCPOA expire after 15 and 25 years	1
Membership	The JCPOA includes 8 signatories: P5 + 1, EU, and Iran	1

of the termination clause has led to fears that Iran will decide to develop and deploy nuclear weapons following the sunset of the agreement.[12]

The existence of a termination clause in the agreement yields a score of 1 for the dichotomous *sunset* indicator used in the ACDD.

8.3.4 Membership

The negotiations of the JCPOA involved the P5+1, Iran itself and, upon signature, the European Union via its High Representative for Foreign Affairs and Security Policy—providing example of a, fairly rare, minilateral arms control regime. Using the dichotomous indicator for multilateralism, this agreement receives a score of 1.

All four design characteristics are summarized in Table 8.1

Using the scores, above, I apply them to the general equation provided by the empirical data from the Arms Control Design Dataset, setting the scores to match the design characteristics of the agreement.

As noted above, I use the coefficients from the equation involving the all of the institutional design parameters of theoretical interest that are the subject of this dissertation and calculated in Chapter 7:

$$\hat{Compliance} = F(2.25 - 0.46(\texttt{AgType}) + 0.17(\texttt{String}) + 0.65(\texttt{Sunset}) + 0.46(\texttt{Multi})) \quad (8.2)$$

Using the estimated coefficients from this equation, I set the values of each variable to the score noted in Table 8.1 and then calculate the predicted probability of compliance using the z-score provided by the probit equation. In this case, the JCPOA has 97.0 percent of compliance on an agreement-year basis.

Bearing in mind that a country failing to comply with its arms control commitments in any given year is fairly rare, is this predicted probability good or bad? To assess this, we need a baseline to compare it to.

[12]Gary G Sick, "Iran After the Deal," *Foreign Affairs*, 2015,

Table 8.2: This table describes the institutional design characteristics associated with New START.

Institutional Design	Score	Score
Agreement Type	New START is primarily an arms limitation agreement	3
Verification Regime	New START employs both information exchanges and on-site inspections for the purposes of verification	2
Termination Clause	New START was negotiated with a termination clause and is slated to end in January 2021	1
Membership	New START involves Russia and the United States	0

8.3.5 The New START Benchmark

In terms of its use of verification provisions, New START is often held up as the "gold standard" of arms control agreements given it's extensive information exchange provisions and on-site inspection regime.

Using the same equation as above, I calculate the predicted probability of compliance of New START's design in any given agreement-year setting the coefficient values to the score outlined in Table 8.2. The predicted probability of compliance with the New START regime on an agreement-year basis is 99.0 percent.

Compared to the benchmark provided by New START using the ACDD dataset, the JCPOA's predicted probability of compliance on an agreement year basis is slightly lower, though not significantly so. Other agreements with the goal of governing nuclear weapons negotiated more recently perform worse.

8.4 Treaty on the Prohibition of Nuclear Weapons

Like the JCPOA discussed above, debates concerning the appropriateness of the 2017 Treaty on the Prohibition of Nuclear Weapons (TPNW) have been polarized between those that argue that existing disarmament efforts among signatories of the NPT are inadequate and, thus, that a new agreement is necessary; and others who suggest that TNPW framework is potentially dangerous both in terms of its lack of verification regime and its consequences for existing arms control arrangements—including the NPT.[13] The Treaty, grown from the a social movement that outlines the humanitarian costs of nuclear weapons and highlights the normative danger of nuclear weapons calls for universal nuclear disarmament.[14] This

[13]Rebecca Davis Gibbons, "The humanitarian turn in nuclear disarmament and the Treaty on the Prohibition of Nuclear Weapons," *The Nonproliferation Review* 25, nos. 1-2 (2018): 11–36; Heather Williams, "A nuclear babel: narratives around the Treaty on the Prohibition of Nuclear Weapons," *The Nonproliferation Review* 25, nos. 1-2 (2018): 51–63.

[14]William C Potter, "Disarmament diplomacy and the nuclear ban treaty," *Survival* 59, no. 4 (2017): 75–108.

movement led to support from a number of governments around the world.

Upon the completion of negotiations in New York, 122 states voted to adopt the Treaty with ratification ongoing. At the time of writing, there are 23 states parties that have signed and ratified the agreement with entry into force to occur upon the 50th signatory depositing their instruments of ratification to the United Nations in New York.

The Treaty's language has been the source of criticism both during the negotiations and since, however, leading to uncertainty concerning whether the agreement will enter into force. I examine the sources of this criticism below while describing the Treaty's design.

8.4.1 Agreement Type

The TPNW seeks to prohibit the development, deployment, and use of nuclear weapons. As Article I, par. 1 notes:

> Each State Party undertakes never under any circumstances to: (a) Develop, test, produce, manufacture, otherwise acquire, possess or stockpile nuclear weapons or other nuclear explosive devices; (b) Transfer to any recipient whatsoever nuclear weapons or other nuclear explosive devices or control over such weapons or explosive devices directly or indirectly; (c) Receive the transfer of or control over nuclear weapons or other nuclear explosive devices directly or indirectly; (d) Use or threaten to use nuclear weapons or other nuclear explosive devices; (e) Assist, encourage or induce, in any way, anyone to engage in any activity prohibited to a State Party under this Treaty; (f) Seek or receive any assistance, in any way, from anyone to engage in any activity prohibited to a State Party under this Treaty; (g) Allow any stationing, installation or deployment of any nuclear weapons or other nuclear explosive devices in its territory or at any place under its jurisdiction or control.[15]

As a result, it is scored as 4 using the agreement typology developed in Chapter 4.

8.4.2 Verification

Article III calls for the use of existing or new comprehensive safeguards agreements monitored by the IAEA (INFCIRC/153 (Corrected)) to verify the agreement. Article 4, par. 6 notes, "States Parties shall designate a competent international authority or authorities to negotiate and verify the irreversible elimination of nuclear-weapons programmes, including the elimination or irreversible conversion of all nuclear -weapons-related facilities in accordance with paragraphs 1, 2 and 3 of this Article." At the time of writing, however, the specifics of this verification regime in terms of information exchange, the use of an on-site or challenge inspection regime remains nuclear.

[15] Art. 1, par. 1, Treaty on the Prohibition of Nuclear Weapons.

Table 8.3: This table describes the institutional design characteristics of the TPNW

Institutional Design	Description	Score
Agreement Type	The TPNW seeks to prohibit the development and deployment of nuclear weapons	4
Verification Regime	The Treaty includes no verification regime	0
Termination Clause	The Treaty is of unlimited duration	0
Membership	The agreement currently has 23 signatores with 50 required for entry into force	1

Given the lack of detail concerning the monitoring and enforcement regime used to verify compliance with the agreement, the agreement is scored as 0 against the categorical *stringency* variable.[16]

8.4.3 Length

Article 17, par. 1 notes that the Treaty will be of unlimited duration. Interestingly, the following paragraph includes a withdrawal provision ubiquitous in international agreements but that is at odds with the language of the Preamble and first article:

> Each State Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of the Treaty have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to the Depositary. Such notice shall include a statement of the extraordinary events that it regards as having jeopardized its supreme interests.[17]

The TPNW is subsequently scored as a 0 for the dichotomous *sunset* variable that captures whether an agreement includes a termination clause.

8.4.4 Membership

The TPNW, as currently drafted, intends to be multilateral in terms of membership and universal in terms of its application. The Treaty, at the time of writing, has 23 signatories and would enter into force with 50 states parties.

The TPNW's design parameters noted above are summarized in Table 8.3.

As with the JCPOA and New START agreements above, I calculate the predicted probability of compliance for the TPNW in a given agreement-year using the scoring from Table

[16]Legal scholars have also pointed to the lack of an explicit verification regime as being a central flaw in the Treaty design.Newell Highsmith and Mallory Stewart, "The nuclear ban treaty: A legal analysis," *Survival* 60, no. 1 (2018): 129–152.

[17]Article 17, par. 2, Treaty on the Prohibiton of Nuclear Weapons.

8.3. In this instance, the predicted probability of compliance on an agreement-year basis is significantly lower than either the JCPOA or New STARt: 81.0 percent. This particular finding suggests that, in line with existing critiques of the institutional design of the Treaty, there may be reason to worry about the institutional design of the TPNW and its consequences for compliance with its provisions in the event that it should enter into force.

8.5 Discussion

As outlined in the chapter above, the ACDD can be used to examine the institutional design of agreements that are not covered in the dataset—including agreements that are currently in the process of negotiation, ratification, or entry into force. While the analysis above is probabilistic based on the training data provided by the Arms Control Design Dataset rather than being predictive, treating the ACDD as training data allows for an empirically grounded discussion concerning the relative consequences of institutional design characteristics used to create arms control regimes and offers an additional basis upon which to engage on questions concerning whether the design of existing or future regimes are appropriate. For example, the Singapore Joint Statement document that seeks to "work toward complete denuclearization of the Korean Peninsula" in a bilateral context without a verification regime or timetable has a considerably lower 66.1 percent predicted probability of compliance on an agreement-year basis compared to those agreements discussed above using the same probit model equation.

This type of analysis will also improve as additional examples and tracking data are added to the dataset. Coding alternative outcome variables beyond compliance with the agreement—from proliferation to conflict data—is also possible to address alternative research questions.

While each of the examples above deal with nuclear weapon technologies, there is also scope for an analysis that employs these methods to consider non-nuclear examples.

The results of the analysis in this chapter also make clear the degree to which design consideration might shape compliance outcomes. In simple terms, and in line with the broader argument of this dissertation, design matters. I reflect on this central proposition in the final chapter to follow.

Chapter 9

Arms Control in the 21st Century

9.1 Introduction: The End of Arms Control?

As I write in July 2019, the prospects of a number of existing arms control regimes appear poor. The United States will withdraw from the INF Treaty, following Russia's non-compliance, in August of 2019 per its exercise of the INF Treaty's withdrawal mechanism. At the same time, it remains unclear whether New START will be extended beyond January 2021. Indeed, the Russian Ambassador to the United States Anatoly Antonov made clear at the Carnegie International Nuclear Policy Conference in March 2019 that Russia prefers re-entering negotiations prior to extension. The use of chemical weapons in Syria despite its designation as a "weapon of mass destruction" and the failure of the existing regime to address this use has led to serious questions concerning compliance within existing arms control regimes. The isolated uses of chemical weapons in Salisbury and Kuala Lumpur by Russia and North Korea, respectively, have also driven renewed calls for condemnation alongside new regulation and governance mechanisms to address military technologies.

This "decline" of arms control has coincided with nuclear modernization in the United States and Russia, the addition of inventory to Chinese nuclear forces, and renewed calls in the 2018 Nuclear Posture Review to build new types of low-yield nuclear weapons.[1] These developments have led a number of former policy-makers to declare that the existing arms control regime is coming to an end.

This reality is further complicated by the use of arms control frameworks by nuclear weapon states (NWS) at past NPT Review Conferences as evidence that they are fulfilling their Article VI obligations.[2] In the event that the contemporary arms control regime involving the United States and Russia is weakened, the Review Conferences of 2020 and 2025 are likely to become increasingly complicated. Furthermore, a majority of non-nuclear weapons states (NNWS) have recently produced and a minority signed the TPNW discussed in the

[1] Hans M Kristensen and Robert S Norris, "Chinese nuclear forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 4 (2018): 289–295.

[2] Article VI calls for the future eradication of nuclear weapons by all states.

previous chapter. While this treaty has a variety of legal issues that potentially undermine the existing nonproliferation regime, it makes clear that NNWS are increasingly impatient with regard to recalcitrance among nuclear weapon-states vis á vis Article VI.[3]

Policy-makers are also faced with the question of how to govern new technologies with various military—and, in some cases, economic—applications.[4] At the same time, calls for the creation of governance frameworks to address new military technologies including drones, cyber weapons, space weaponry, hypersonic missiles, and technologies associated with artificial intelligence continue even as what many have described as a renewed arms race heats up.[5] What these governance mechanisms should look like, however, remains unclear—despite several discussions concerning arms control pertaining to frontier non-nuclear technologies at the United Nations via various Group of Governmental Expert (GGE) processes and under the Convention on Certain Conventional Weapons processes (CCW).

The combination of the realities noted above raises serious questions concerning the future of arms control and how to appropriately design future regimes.[6] To assess the prospects and future of arms control in the 21st century in light of the challenges noted above, this project sought to examine the effects of arms control frameworks first established to govern dreadnoughts and submarines that were subsequently re-tasked to address the numbers of intercontinental ballistic missiles, biological weapons, and directed energy weapons. This final chapter serves as a summary of the analysis that came before and a call to action to continue to work of tracking the design and use of arms control into the future. The chapter also reflects on new questions for scholarly inquiry that stem from the analysis presented in these pages.

9.2 Summary of Findings

The central theme that runs throughout the dissertation is that, design matters—at least as we analyze and assess the effects of various institutional design characteristics on episodes of compliance and non-compliance in the historical record. One of the strengths of the analysis carried out in these pages, however, is the ability to isolate and begin theorizing around *how* design matters.

[3]Highsmith and Stewart, "The nuclear ban treaty: A legal analysis."

[4]The "dual-use" nature of a number of these capabilities represents a challenge to those wishing to regulate the technology given the existence of private actors lobbying for nonintervention.

[5]Stuart Russell et al., "Ethics of artificial intelligence," *Nature* 521, no. 7553 (2015): 415–416; Edward Moore Geist, "It's already too late to stop the AI arms race: We must manage it instead," *Bulletin of the Atomic Scientists* 72, no. 5 (2016): 318–321; Michael Horowitz et al., "Strategic Competition in an Era of Artificial Intelligence," *Center for New American Security (Washington, DC: Center for New American Security, 2018)* 8 (2018); Mariarosaria Taddeo and Luciano Floridi, "Regulate artificial intelligence to avert cyber arms race," 2018,

[6]Rebecca Davis Gibbons, "The Future of the Nuclear Order," *Arms Control Today* 49, no. 3 (2019): 12–16.

9.2.1 Agreement Type and Ambition

In Chapter 4, I examine how the scope—or type—of an agreement shapes compliance outcomes. In the process, I compare patterns of compliance and non-compliance among agreements designed to *prohibit* the development and deployment of nuclear weapons, agreements designed to *limit* the development and deployment of nuclear weapons, agreements designed to *ban testing* of nuclear weapons, and softer agreements that seek to *control* nuclear technology for the purposes of nuclear risk reduction. In the analysis, I find that agreements that are more ambitious in terms of constraining state behavior are at increased risk of non-compliance. This is not to suggest that efforts to prohibit the development of weapon technologies are inappropriate—only to note that prohibition represents a hard task, despite the relative ease of monitoring these agreements compared to arms limitation agreements.[7]

9.2.2 A "Goldilocks" Level of Verification

In Chapter 5, I examine how varying types of verification regimes shaped patterns of compliance to test whether the conventional wisdom that stringent and intrusive verification regimes perform best. In the process, I also consider the variation in the types of institutions charged with monitoring arms control regimes. Interestingly, my analysis of the empirical record finds that the most intrusive types of verification are not, as is currently believed, more or most likely to lead to compliance. Rather, the past examples of arms control agreements suggest that there is an "n-curve" in which those agreements with no enforcement mechanisms and the most intrusive monitoring procedures fare poorly while those with "just enough" verification perform relatively well.

9.2.3 The Sunset Benefit

In Chapter 6, I compare those agreements that are designed to last in perpetuity to those agreements that include a termination clause after a specific period of time. Interestingly, and again contrary to the notion that agreements of "indefinite duration" are the most desirable, those agreements that include termination clauses perform better—in terms of compliance outcomes—than those designed to last forever.

9.2.4 Membership May Not Matter

In the final quantitative chapter, I analyze how the membership of an agreement might affect compliance outcomes—spending much of the chapter focusing on the relative performance of bilateral and multilateral agreements and testing a number of theories associated with the consequences of multilateralism on international cooperation.[8] While there is documented

[7]States parties must determine and agree to mechanisms to count the numbers of warheads or delivery vehicles being regulated in the latter.

[8]Kahler, "Multilateralism with small and large numbers."

disagreement in the existing literature over the relative benefits of bilateral, minilateral, and multilateral frameworks, the analysis of existing arms control agreements suggests that membership may matter less than currently believed.

9.2.5 Applications: JCPOA and TPNW

In Chapter 8, I apply the ACDD as training data to reflect on the institutional design of several contemporary arms control negotiations. First, I examine the Joint Comprehensive Plan of Action (JCPOA) benchmarked against New START and find that its design yielded a high predicted probability of compliance. Second, I consider the design of the completed Treaty on the Prohibition of Nuclear Weapons (TPNW), or "Ban Treaty," that attempts to ban all nuclear weapons. In part due to the absence of a verification regime, the TPNW's predicted probability of compliance is substantially lower than either New START or the JCPOA—though not as low as the Singapore Joint Statement that altogether lacks an institutional framework. In the process, I argue that this dataset represents a new tool in the methodological toolkit with which to engage with scholarly inquiry concerning institutional design and its consequences.

9.3 Theoretical Implications

For the purposes of institutional design theory, the analysis described above leaves us with reason to question the conventional wisdom, driven in large part by scholarship on non-security regimes,[9] concerning the monitoring and verification, the desirability of termination clauses, and the advantages of multilateral frameworks. Of course, and as noted in the prior chapters, more work is needed to assess the "causes" of the patterns outlined in the dissertation given the questions raised by the analysis in these pages. The chapter examining verification, in particular, represents a useful source for further analysis given the surprising findings and the potential for new theoretical concerning institutional pathologies applied to arms control—particularly as non-strategic arms control agreements are added to the dataset.

The dissertation also demonstrates a quantitative approach to the analysis of institutional design that might be usefully mirrored in a treatment of non-security regimes—whether related to climate change or international economics—to ascertain the degree to which a "high politics"-"low politics" distinction drives these outcomes.

[9]There is, as I note in Chapter 2, a considerable literature related to the design of peace agreements following war. While many of these agreements involve both state and non-state actors, multiple states are often involved in the negotiation and enforcement of agreements. For more on this, see: Walter, "Designing transitions from civil war: Demobilization, democratization, and commitments to peace"; Fortna, "Scraps of paper? Agreements and the durability of peace"; Werner and Yuen, "Making and keeping peace"; Mattes and Savun, "Fostering peace after civil war: Commitment problems and agreement design"; Matanock, *Electing Peace: From Civil Conflict to Political Participation*; Fortna, *Peace time: Cease-fire agreements and the durability of peace.*

More broadly, the findings presented here also suggest that international institutions have a role in mediating outcomes and that, even with unexpected outcomes, "form follows function."

As well as these theoretical considerations, the dissertation has at least two practical implications. In the sections below, I turn to how this analysis addresses the future of nuclear arms control before turning to the creation of governance arrangements for emerging technologies.

9.4 An (Optimistic?) Future for Strategic Arms Control

There is, as noted in Chapter 8, a series of practical, policy-relevant implications of the research carried out in this dissertation when it comes to contemporary arms control design.

Taking the INF as an example, there are three options facing Washington and Moscow outside of the United States, Russia, or both withdrawing from the Treaty, thereby removing both sides from their Treaty obligations. Should withdrawal occur, however, Washington and Moscow face the decision of whether to revisit arms control for intermediate-range forces, individually, or as part of broader nuclear arms control negotiations. Each of the three options come with its intrinsic costs and benefits.

The first option, previously rejected by Washington, is to continue to muddle through the status quo INF Treaty regime without a verification regime to monitor compliance, but keeping the existing treaty architecture intact in the hopes that Russia once again comes into compliance. This outcome would represent a climb-down for the United States and potentially require concessions from Moscow while failing to re-institute lapsed verification regime. The second option is to amend the Treaty regime and reach an understanding concerning a reinvigorated inspection regime. Past statements made by senior U.S. officials suggest that this would be necessary for the INF Treatys survival. The analysis in the previous chapters suggest that a combination of information exchanges and on-site inspections represent the most appropriate path forward. The final, and perhaps most challenging, option would provide an opportunity to renegotiate the verification and enforcement architecture concerning intermediate-range forces, while attempting to broaden the membership to other states. It remains to be seen which option policy-makers choose, though it looks increasingly likely that Washington and Moscow will allow the Treaty to lapse following the exercise of its withdrawal in August 2019.

The likely end of the INF Treaty has also called into question the survival of the broader arms control regime as the existing New START regime sunsets in 2021 unless both Washington and Moscow agree to extend the Treaty until 2026. Past negotiators, including the former head of the U.S. delegation to START I, have described the current era as being the first in which there are no limits on the numbers of nuclear weapons deployed by the United States and Russia—despite arms limitation agreements representing the most successful types of

arms control agreements included in the ACDD.

While the extension of formal, binding agreements with extensive verification regimes and of infinite duration to limit the number of nuclear weapons is no doubt desirable, the analysis presented here suggests that time-bound, informal, norms-based frameworks with less stringent verification mechanisms and a larger number of members may adequately pick up the slack. As the data included within the ACDD continues to grow, debates surrounding the appropriate design of arms control agreements and enforcement regimes might better consider how to maximize outcomes of interest and use institutional design as a vehicle for doing so.

9.5 Governing Emerging Technologies

As noted in Chapter 3, the selection criteria for the ACDD involved using Kreps's selection of arms control regimes focused on nuclear weapons. Arms control, as the Geneva Conventions and the Washington Naval Treaty attest, need not involve weapons with existential consequences. Indeed, a number of contemporary conventional military technologies are the subject of nascent intergovernmental efforts to regulate and govern their use. In this section, I consider a number of technologies that have been mentioned throughout the dissertation as well as nascent state of regulatory discussions surrounding them: unmanned aerial vehicles or "drones" (UAVs), artificial intelligence technologies, cyber weapons, hypersonic missiles, and space weapons.

There are multiple drivers of innovation in military technologies, not least the war-fighting benefits associated with them including force multiplication and offset capabilities.[10] New technologies may also allow weapon to be more discerning or removing soldiers from the battlefield, saving the lives of soldiers and civilians. The challenge for prospective governance regimes, however, is to maintain the benefits of emerging technologies while minimizing their costs—whether in terms of arms racing or destabilizing consequences. Taken together, these emerging technologies present a number of challenges addressed throughout the preceding chapters.

9.5.1 Drone Warfare, Artificial Intelligence, and the GGE

As Horowitz, Kreps, and Fuhrmann point out, separating fact from fiction amid the hysteria surrounding the proliferation of "drones"—unmanned aerial and, recently, underwater vehicles—has become increasingly difficult.[11] While some suggest that these technologies change everything by reducing the costs of engaging in conflict, others are more sanguine

[10]Horowitz, *The diffusion of military power: Causes and consequences for international politics.*

[11]Michael C Horowitz, Sarah E Kreps, and Matthew Fuhrmann, "Separating fact from fiction in the debate over drone proliferation," *International Security* 41, no. 2 (2016): 7–42.

about their impacts.[12] Nascent efforts to regulate unmanned vehicles have also found their way into broader discussions in Geneva concerning the legality and ethics of using "killer robots."[13]

These regulatory discussions have taken place in intergovernmental forums under the auspices of the Convention on Certain Conventional Weapons (CCW) with support provided by the United Nations—via the UN Office for Disarmament Affairs (UNODA). The Group of Governmental Experts on Lethal Autonomous Weapons Systems (GGE LAWS), established in 2016, met most recently in March of 2019 with little progress made toward a pre-emptive ban on lethal autonomous weapons despite sustained lobbying from Human Rights Watch and the Campaign to Stop Killer Robots. As far as concrete accomplishments, the GGE has focused the conversation on the degree to which humans have—or ought to have—control over military technologies amid fears that "black-box" algorithms will determine who lives and who dies.[14] This has led to a series of discussions concerning the appropriateness of maintaining a "human in the loop" or "human on the loop." The U.S. Department of Defense Directive 3000.09, for example, requires that all military systems "allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[15]

What this Directive and intergovernmental meetings fail to take into account, however, is that autonomous systems have already been developed and deployed on the battlefield. As a recent SIPRI study notes, there are upwards of fifty deployed autonomous or semi-autonomous weapon systems currently used in militaries around the world.[16] A number of these systems—particularly missile defense systems—derive their very utility from the very fact that they are autonomous in nature. Indeed, one of clear challenges facing efforts to negotiate and design arms control to address autonomous military technologies are the significant benefits derived from non-compliance and the potential for "race to the bottom" dynamics as autonomous technologies proliferate.

9.5.2 The Difficulty of Defining a Domain: "Cyber"

The pursuit of arms control involving cyber weapons has been similarly difficult—particularly in terms of defining the very military technology that some would like to see regulated. Unlike bombers that can be monitored from satellite imagery or warheads that can counted by on-site weapon inspectors, malicious software cannot be readily monitored. As a result, most

[12]Erik Lin-Greenberg, "Game of Drones: The Effect of Remote Warfighting Technology on Conflict Escalation (Evidence from Wargames)," *Available at SSRN 3288988*, 2018,

[13]Armin Krishnan, *Killer robots: legality and ethicality of autonomous weapons* (Routledge, 2016).

[14]Zachary S Davis, *Artificial Intellience on the Battlefield* (Center for Global Security Research, LLNL, 2019); Geist, "It's already too late to stop the AI arms race: We must manage it instead"; Daniel S Hoadley and Nathan J Lucas, *Artificial intelligence and national security* (Congressional Research Service, 2018); Amitai Etzioni and Oren Etzioni, "Should Artificial Intelligence Be Regulated?," *Issues in Science and Technology, Summer*, 2017, Matthew U Scherer, "Regulating artificial intelligence systems: Risks, challenges, competencies, and strategies," *Harv. JL & Tech.* 29 (2015): 353.

[15]U.S. Department of Defense Directive 3000.09, November 2', 2012

[16]Boulanin, *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk*.

existing arms control efforts—including two competing UN GGE processes—to address cyber weapons focus on their effects rather than regulating the weapon itself. The Obama-Xi San Francisco Summit in September 24-25, 2015, for example, led to the U.S.China Cyber Agreement. The agreement itself called for both sides to "provide timely responses to requests for information and assistance concerning malicious cyber activities, refrain from conducting or knowingly supporting cyber-enabled theft of intellectual property, pursue efforts to further identify and promote appropriate norms of state behavior in cyberspace within the international community, and establish a high-level joint dialogue mechanism on fighting cybercrime and related issues." The agreement itself was borne out of efforts to address both economic espionage and to address attacks to critical infrastructure—communication networks, energy grids, water systems, and financial networks.

Overall, cooperative mechanisms to address subsidiary challenges such as cybercrime—via the Budapest Convention—have been more successful thus far than efforts to create an "International Cybersecurity Agreement" like the Paris Call for Trust and Security in Cyberspace ("Paris Call") that, while lacking an enforcement mechanism, attempts to spell out appropriate and inappropriate behavior on the part of both governments and private sector actors.

In many of the regulatory discussions, the Outer Space Treaty (OST) has been held up as a model of arms control. However, space, too, is increasingly "congested, competitive, and contested."[17]

9.5.3 Space Weapons and the Outer Space Treaty

The OST, included in the Arms Control Design Dataset, seeks to address space as a venue for military competition. The Treaty, signed in 1967, prohibits the stationing of weapons of mass destruction in outer space. The Treaty also mandates that the Moon and other celestial bodies be used only for "peaceful purposes." The Treaty has not been without controversy, however, as surface-deployed anti-satellite weapons (ASATs) of the missile and directed energy variety as well as missile defense systems have been accused of falling afoul of the Treaty's terms.

The OST also does not prevent states from stationing conventional weapons in space. In years past, this may not have been a significant problem. Recently, however, a number of states have deployed space-facing ISR capabilities while also interfering with the operations of adversary satellites. In response to these challenges France's Defense Minister, Florence Parly, outlined plans to deploy swarms of nano-satellites that patrol around French satellites, a ground-based laser to blind snooping satellites, and anti-satellite projectiles to placed on board future satellites as part of President Macron's broader effort to protect its space assets. The efforts are mirrored elsewhere as space becomes a domain for both intelligence collection and kinetic effects.

[17]Roger G Harrison, *Astropolitics* 11, no. 3 (2013): 123–131.

The militarization of space opens up an important venue for new cooperative mechanisms to address the deployment and use of non-strategic arms in space. As states engage on the appropriateness of deployment and use of military technologies, the design characteristics alluded to throughout this dissertation are once again likely to be central.

9.5.4 The Limits of the MTCR: Hypersonic Missiles

The final technology considered in this section are a new class of long-range, maneuverable missile systems designed to overcome both established and nascent missile defense capabilities. These hypersonic capabilities—that travel at five times the speed of sound with a capability to deliver both conventional and nuclear payloads and evade existing missile defense systems—come in two flavors. The first involves a hypersonic glide vehicle that is launched on a ballistic trajectory and is maneuvered as it falls. The second is a re-designed cruise missile powered by a supersonic combustion ramjet.

Like a number of emerging technologies discussed in this section, the development of hypersonic missiles have led to fears that its deployment will have deleterious consequences for strategic stability—and that existing Missile Technoloy Control Regime (MTCR) regulatory framework that primarily relies on export controls is inadequate to arrest the proliferation of the technology.[18] While hypersonic missiles do not easily fall into existing arms control arrangements, the reliance of most hypersonic missile designs on ballistic trajectories during their boost phase and the regulation of the numbers of ballistic delivery vehicles under the New START suggest that New START's replacement—should it come to fruition—likely offers the most appropriate place to start a regulatory discussion concerning this new type of weapon. That said, it is also possible that an entirely new governance regime be created to address hypersonic capabilities, specifically. It also possible, given the asymmetrical investments in hypersonic capabilities, that they become subject to an asymmetrical arms control regime in which capabilities in one area are traded off in another.

As the two sections above make clear, there are a large number of challenges facing arms control in the coming decade at the same time as the cooperative frameworks that scholars and policy-makers had previously taken for granted increasingly come under pressure. As negotiators take part in the ensuing rounds of arms control negotiations and design the institutions of the future, lessons can and should be learned from the past and applied to the future.

Indeed, it is worth revisiting the arms control life cycle, Figure 9.1 outlined in Chapter 1.

Most of the emerging technologies noted above are in the earliest stage of this life cycle—securitization. Artificial intelligence technologies perhaps offer the most obvious example of a contemporary technology that is increasingly discussed in "security" terms—despite its

[18]Torben Schutz, "Technology and Strategy: Hypersonic Weapon Systems Will Decrease Global Strategic Stability-and Current Control Regimes Won't Do," 2019, I also spell out these fears in a 2018 article for the Center for Strategic and International Studies: Andrew Reddie, "Hypersonic Hysteria: Examining the Hypersonic Hammer," *Center for Strategic and International Studies*, 2018,

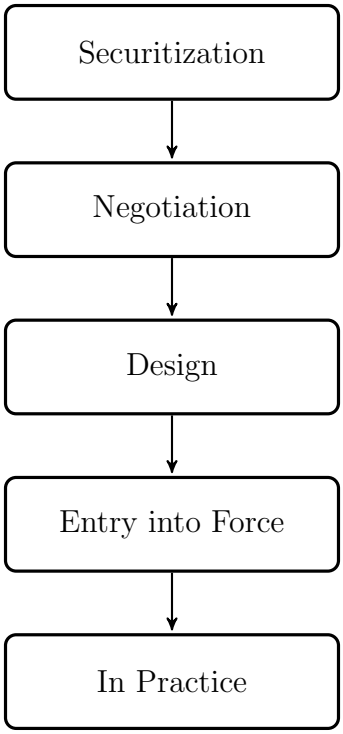

Figure 9.1: This figure summarizes the stages of arms control as a process

long-time use in statistics and data analysis. While this study focuses on the negotiation, design, and practice of arms control rather than securitization, the latter is, clearly, an important subject for future study—particularly as it relates to "who" gets to decide "what" is securitized.

9.6 Future Research

To address the emerging policy challenges as well as the older challenges posed by nuclear weapons noted above, this dissertation project posits that there are a large number of arms control frameworks from which to empirically draw lessons and comparisons—in terms of both their respective designs and outcomes. There is also adequate empirical data with which to conclude that, contrary to scholarship suggesting that international institutions offer only epiphenomenal effects, design matters.

Moving forward, there are a number of avenues of further research that stem from this project—not least continuing to expand the dataset to include new agreements, non-strategic agreements, country-level data, and new types of design data.[19]

[19]Given the difficulties associated with creating qualitative indicators of Treaty performance, I focus my analysis on those Treaty characteristics that could be directly coded from Treaty text with little interpolation.

The first and most obvious avenue for future research involves treating the Arms Control Design Dataset as an outcome variable rather than the independent variable to answer a related but different research question: Under what conditions do states create arms control frameworks with specific institutional design characteristics?

The second avenue for research involves a series of case studies engaged with contemporary arms control debates that outlines the design choices under consideration and employs machine learning approaches, one of which is outlined in Chapter 8, to consider the probabilistic consequences of design decisions.

A third avenue for future research involves the application of these institutional design considerations to venues beyond arms control. Other types of international agreements, from ceasefires to trade agreements and environmental accords can usefully be analyzed on the basis of their design characteristics and the record of compliance among states parties. Examining contexts outside of arms control might allow for a generalizable theory of compliance—or a renewed focus on the differences between "high politics," on the one hand, and "low politics," on the other.

In closing, this analysis sought to augment a conversation concerning the design of arms control that often relied on heuristics and personal experience rather than the empirical record. In the process, it provides a scientifically and empirically grounded discussion concerning the consequences of institutional design to answer questions concerning the consequences of institutional design of arms control on compliance outcomes—combining both the literature and methods of inquiry from international political economy and international security. The dissertation provides answers to questions concerning the scope, verification, length, and membership of agreements, while posing many more.

Future analysis may be more ambitious in this regard.

Bibliography

Aakre, Stine, Leif Helland, and Jon Hovi. "When does informal enforcement work?" *Journal of Conflict Resolution* 60, no. 7 (2016): 1312–1340.

Abbott, Kenneth W. "Trust but verify: The production of information in arms control treaties and other international agreements." *Cornell International Law Journal* 26 (1993): 1.

Abbott, Kenneth W, Robert O Keohane, Andrew Moravcsik, Anne-Marie Slaughter, and Duncan Snidal. "The concept of legalization." *International Organization* 54, no. 3 (2000): 401–419.

Abbott, Kenneth W, and Duncan Snidal. "Hard and soft law in international governance." *International Organization* 54, no. 3 (2000): 421–456.

Adler, Emanuel. "The emergence of cooperation: national epistemic communities and the international evolution of the idea of nuclear arms control." *International Organization* 46, no. 1 (1992): 101–145.

Aggarwal, Vinod K. *Institutional designs for a complex world: Bargaining, linkages, and nesting*. Cornell University Press, 1998.

———. *Liberal protectionism: The international politics of organized textile trade*. Vol. 13. Univ of California Press, 1985.

Altmann, Jurgen, and Frank Sauer. "Autonomous weapon systems and strategic stability." *Survival* 59, no. 5 (2017): 117–142.

Association, Arms Control, et al. *The intermediate-range nuclear forces (INF) treaty at a glance*, 2017.

Axelrod, Robert, and Douglas Dion. "The further evolution of cooperation." *Science* 242, no. 4884 (1988): 1385–1390.

Axelrod, Robert, and Robert O Keohane. "Achieving cooperation under anarchy: Strategies and institutions." *World Politics* 38, no. 1 (1985): 226–254.

Bailey, Michael A, Anton Strezhnev, and Erik Voeten. "Estimating dynamic state preferences from United Nations voting data." *Journal of Conflict Resolution* 61, no. 2 (2017): 430–456.

Banks, Arthur S, and Kenneth A Wilson. "Cross-National Time-Series Data Archive." *Databanks International*, 2013.

Barrett, Scott. "A theory of full international cooperation." *Journal of Theoretical Politics* 11, no. 4 (1999): 519–541.

Beck, Nathaniel, Jonathan N Katz, and Richard Tucker. "Taking time seriously: Time-series-cross-section analysis with a binary dependent variable." *American Journal of Political Science* 42 (1998): 1260–1288.

Benvenisti, Eyal, and George W Downs. "The empire's new clothes: political economy and the fragmentation of international law." *Stan. L. Rev.* 60 (2007): 595.

Betts, Richard K. "Systems for peace or causes of war? Collective security, arms control, and the new Europe." *International Security* 17, no. 1 (1992): 5–43.

Biswas, Atanu, Samarjit Das, and Soumyadeep Das. "OLS: Is That So Useless for Regression with Categorical Data?" In *Advances in Analytics and Applications*, 227–242. Springer, 2019.

Bode, Ingvild, and Hendrik Huelss. "Autonomous weapons systems and changing norms in international relations." *Review of International Studies* 44, no. 3 (2018): 393–413.

Bohlen, Avis. "The rise and fall of arms control." *Survival* 45, no. 3 (2003): 7–34.

Booth, Ken, and Nicholas Wheeler. *The security dilemma: Fear, cooperation, and trust in world politics*. Springer Nature, 2007.

Boulanin, Vincent. *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk*. Technical report. SIPRI, 2019.

Brodie, Bernard. "Nuclear weapons: strategic or tactical?" *Foreign Affairs* 32, no. 2 (1954): 217–229.

Bull, Hedley. "The Control of the Arms Race: Disarmament and Arms Control in the Missile Age.(Studies in International Security, II.)" *The Annals of the American Academy of Political and Social Science*, 1962.

Burns, Richard Dean. "Arms Control and Disarmament." *A Bibliography. Santa Barbara*, 1977.

———. *The evolution of arms control: from antiquity to the nuclear age*. Praeger Security International, 2009.

Carter, David B, and Curtis S Signorino. "Back to the future: Modeling time dependence in binary data." *Political Analysis* 18, no. 3 (2010): 271–292.

Chayes, Abram. "An inquiry into the workings of arms control agreements." *Harvard Law Review*, 1972, 905–969.

Chayes, Abram, and Antonia Handler Chayes. "Compliance without enforcement: state behavior under regulatory treaties." *Negotiation Journal* 7, no. 3 (1991): 311–330.

———. "On compliance." *International Organization* 47, no. 2 (1993): 175–205.

Copelovitch, Mark S, and Tonya L Putnam. "Design in context: existing international agreements and new cooperation." *International Organization* 68, no. 2 (2014): 471–493.

Croft, Stuart. *Strategies of arms control: a history and typology*. Manchester University Press, 1996.

Daalder, Ivo H. "The future of arms control." *Survival* 34, no. 1 (1992): 51–73.

Dafoe, Allan. "AI Governance: A Research Agenda." *Governance of AI Program, Future of Humanity Institute, University of Oxford: Oxford, UK*, 2018.

Davis, Zachary S. *Artificial Intellience on the Battlefield*. Center for Global Security Research, LLNL, 2019.

Debs, Alexandre, and Nuno P Monteiro. *Nuclear Politics*. Vol. 142. Cambridge University Press, 2016.

Downs, George W, David M Rocke, and Peter N Barsoom. "Is the good news about compliance good news about cooperation?" *International Organization* 50, no. 3 (1996): 379–406.

Duffy, Gloria. "Arms control treaty compliance." *Encyclopedia of arms control and disarmament* 1 (1993): 279.

Eckersley, Robyn. "Moving forward in the climate negotiations: Multilateralism or minilateralism?" *Global Environmental Politics* 12, no. 2 (2012): 24–42.

Etzioni, Amitai, and Oren Etzioni. "Should Artificial Intelligence Be Regulated?" *Issues in Science and Technology, Summer*, 2017.

Falkner, Robert. "A minilateral solution for global climate change? On bargaining efficiency, club benefits, and international legitimacy." *Perspectives on Politics* 14, no. 1 (2016): 87–101.

Fearon, James D. "Bargaining, enforcement, and international cooperation." *International Organization* 52, no. 2 (1998): 269–305.

———. "Rationalist explanations for war." *International Organization* 49, no. 3 (1995): 379–414.

Findlay, Trevor. "IAEA Noncompliance Reporting And the Iran Case." *Arms Control Today* 46, no. 1 (2016): 30.

Fitzpatrick, Mark. "Iran: A good deal." *Survival* 57, no. 5 (2015): 47–52.

Fortna, Virginia Page. *Peace time: Cease-fire agreements and the durability of peace*. Princeton University Press, 2018.

———. "Scraps of paper? Agreements and the durability of peace." *International Organization* 57, no. 2 (2003): 337–372.

Fuhrmann, Matthew. "When Preventive War Threats Work for Nuclear Nonproliferation." *The Washington Quarterly* 41, no. 3 (2018): 111–135.

Fuhrmann, Matthew, and Yonatan Lupu. "Do arms control treaties work? Assessing the effectiveness of the nuclear nonproliferation treaty." *International Studies Quarterly* 60, no. 3 (2016): 530–539.

Gallagher, Nancy W. "Bridging the gaps on arms control." *Contemporary Security Policy* 18, no. 2 (1997): 1–24.

———. "The politics of verification: Why 'how much?' is not enough." *Contemporary Security Policy* 18, no. 2 (1997): 138–170.

Gampfer, Robert. "Minilateralism or the UNFCCC? The political feasibility of climate clubs." *Global Environmental Politics* 16, no. 3 (2016): 62–88.

Garcia, Denise. "Future arms, technologies, and international law: Preventive security governance." *European Journal of International Security* 1, no. 1 (2016): 94–111.

———. *Small arms and security: new emerging international norms*. Routledge, 2006.

Gardner, Richard N. "Sterling-dollar diplomacy in current perspective." *International Affairs (Royal Institute of International Affairs 1944-)* 62, no. 1 (1985): 21–33.

Gartzke, Erik, and Matthew Kroenig. "Nukes with numbers: empirical research on the consequences of nuclear weapons for international conflict." *Annual Review of Political Science* 19 (2016): 397–412.

———. "Social Scientific Analysis of Nuclear Weapons: Past Scholarly Successes, Contemporary Challenges, and Future Research Opportunities." *Journal of Conflict Resolution* 61, no. 9 (2017): 1853–1874.

Gasser, Urs, and Virgilio AF Almeida. "A layered model for AI governance." *IEEE Internet Computing* 21, no. 6 (2017): 58–62.

Gavin, Francis J. "Same As It Ever Was: Nuclear Alarmism, Proliferation, and the Cold War." *International Security* 34, no. 3 (2010): 7–37.

Geist, Edward Moore. "It's already too late to stop the AI arms race: We must manage it instead." *Bulletin of the Atomic Scientists* 72, no. 5 (2016): 318–321.

Gelpi, Christopher, and Joseph M Grieco. "Attracting trouble: Democracy, leadership tenure, and the targeting of militarized challenges, 1918-1992." *Journal of Conflict Resolution* 45, no. 6 (2001): 794–817.

Gerson, Allan. "Multilateralism a la carte: the consequences of unilateral 'pick and pay' approaches." *European Journal of International Law* 11, no. 1 (2000): 61–65.

Gibbons, Rebecca Davis. "The Future of the Nuclear Order." *Arms Control Today* 49, no. 3 (2019): 12–16.

———. "The humanitarian turn in nuclear disarmament and the Treaty on the Prohibition of Nuclear Weapons." *The Nonproliferation Review* 25, nos. 1-2 (2018): 11–36.

Glaser, Charles L, and Chairn Kaufmann. "What is the offense-defense balance and how can we measure it?" *International security* 22, no. 4 (1998): 44–82.

Goldblat, Jozef. *Arms control: a survey and appraisal of multilateral agreements*. Taylor & Francis Ltd, 1978.

———. *Arms Control: The New Guide to Negotiations and Agreements*. Sage, 2002.

Gray, Colin S. "Arms control does not control arms." *Orbis* 37, no. 3 (1993): 333–348.

Graybeal, Sidney N, and Michael Krepon. "Making better use of the standing consultative commission." *International Security* 10, no. 2 (1985): 183–199.

Greenland, Sander, Judith A Schwartzbaum, and William D Finkle. "Problems due to small samples and sparse data in conditional logistic regression analysis." *American Journal of Epidemiology* 151, no. 5 (2000): 531–539.

Greig, J Michael, and Andrew J Enterline. "National Material Capabilities (NMC) Data Documentation Version 5.0." *Correlates of War* 27 (2017).

Grieco, Joseph M. *Cooperation among nations: Europe, America, and non-tariff barriers to trade*. Cornell University Press, 1990.

———. "Realist theory and the problem of international cooperation: Analysis with an amended prisoner's dilemma model." *The Journal of Politics* 50, no. 3 (1988): 600–624.

Grigsby, Alex. "The end of cyber norms." *Survival* 59, no. 6 (2017): 109–122.

Guthe, Kurt, Susan Koch, Thomas Scheber, Robert Joseph, and Keith Payne. "Securing Compliance with Arms Control Agreements," 2016.

Gutner, Tamar, and Alexander Thompson. "The Politics of IO Performance: A Framework." . *The Review of International Organizations* 5, no. 3 (2010): 227–248.

Haas, Peter M. "Compliance with EU directives: insights from international relations and comparative politics." *Journal of European Public Policy* 5, no. 1 (1998): 17–37.

Haas, Peter M, et al. *Knowledge, power, and international policy coordination*. University of South Carolina Press Columbia, SC, 1992.

Hafemeister, David, Kosta Tsipis, and JJ ROMM. "The verification of compliance with arms-control agreements." *Scientific American* 252, no. 3 (1985): 29–35.

Hafner-Burton, Emilie M. "Sticks and stones: Naming and shaming the human rights enforcement problem." *International Organization* 62, no. 4 (2008): 689–716.

Hafner-Burton, Emilie M, Stephan Haggard, David A Lake, and David G Victor. "The behavioral revolution and international relations." *International Organization* 71, no. S1 (2017): S1–S31.

Haggard, Stephan, and Beth A Simmons. "Theories of international regimes." *International Organization* 41, no. 3 (1987): 491–517.

Hansen, Susanne Therese. "Taking ambiguity seriously: Explaining the indeterminacy of the European Union conventional arms export control regime." *European Journal of International Relations* 22, no. 1 (2016): 192–216.

Harrison, Roger G. *Astropolitics* 11, no. 3 (2013): 123–131.

Heckman, James J. "The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models." In *Annals of Economic and Social Measurement, Volume 5, number 4*, 475–492. NBER, 1976.

Highsmith, Newell, and Mallory Stewart. "The nuclear ban treaty: A legal analysis." *Survival* 60, no. 1 (2018): 129–152.

Hoadley, Daniel S, and Nathan J Lucas. *Artificial intelligence and national security*. Congressional Research Service, 2018.

Hoffmann, Wolfgang, Rashad Kebeasy, and Petr Firbas. "Introduction to the verification regime of the Comprehensive Nuclear-Test-Ban Treaty." *Physics of the Earth and Planetary Interiors* 113, nos. 1-4 (1999): 5–9.

Horowitz, Michael C. *The diffusion of military power: Causes and consequences for international politics*. Princeton University Press, 2010.

———. "When Speed Kills: Autonomous Weapon Systems, Deterrence, and Stability." *Deterrence and Stability*, 2019.

Horowitz, Michael C, Sarah E Kreps, and Matthew Fuhrmann. "Separating fact from fiction in the debate over drone proliferation." *International Security* 41, no. 2 (2016): 7–42.

Horowitz, Michael, Gregory Allen, Elsa Kania, and Paul Scharre. "Strategic Competition in an Era of Artificial Intelligence." *Center for New American Security (Washington, DC: Center for New American Security, 2018)* 8 (2018).

Hyde-Price, Adrian. "'Normative' power Europe: a realist critique." *Journal of European Public Policy* 13, no. 2 (2006): 217–234.

Jervis, Robert. "Cooperation under the security dilemma." *World Politics* 30, no. 2 (1978): 167–214.

———. "From balance to concert: a study of international security cooperation." *World Politics* 38, no. 1 (1985): 58–79.

Jupille, Joseph, Joseph Henri Jupille, Walter Mattli, and Duncan Snidal. *Institutional choice and global commerce*. Cambridge University Press, 2013.

Kahler, Miles. "Evolution, choice, and international change." *Strategic Choice and International Relations*, 1999, 165–96.

———. "Multilateralism with small and large numbers." *International Organization* 46, no. 3 (1992): 681–708.

Kapur, S Paul. "India and Pakistan's Unstable Peace: Why Nuclear South Asia Is Not Like Cold War Europe." *International Security* 30, no. 2 (2005): 127–152.

Keck, Margaret E, and Kathryn Sikkink. *Activists beyond borders: Advocacy networks in international politics*. Cornell University Press, 2014.

Keohane, Robert O. "Multilateralism: an agenda for research." *International Journal* 45, no. 4 (1990): 731–764.

Keohane, Robert O, Stephen Macedo, and Andrew Moravcsik. "Democracy-enhancing multilateralism." *International Organization* 63, no. 1 (2009): 1–31.

Keohane, Robert O, and Lisa L Martin. "The promise of institutionalist theory." *International Security* 20, no. 1 (1995): 39–51.

King, Gary, and Richard Nielsen. "Why propensity scores should not be used for matching." *Political Analysis*, 2016, 1–20.

King, Gary, Michael Tomz, and Jason Wittenberg. "Making the most of statistical analyses: Improving interpretation and presentation." *American Journal of Political Science*, 2000, 347–361.

Kissinger, Henry, and George P Shultz. "The Iran deal and its consequences." *Wall Street Journal*, 2015.

Koremenos, Barbara. "Loosening the ties that bind: A learning model of agreement flexibility." *International Organization* 55, no. 2 (2001): 289–325.

Koremenos, Barbara, Charles Lipson, and Duncan Snidal. "The rational design of international institutions." *International organization* 55, no. 4 (2001): 761–799.

Krasner, Stephen D. *International regimes*. Cornell University Press, 1983.

Krause, Keith R. *Culture and security: multilateralism, arms control and security building*. Routledge, 2012.

Krause, Keith, and Andrew Latham. "Constructing non-proliferation and arms control: The norms of Western practice." *Contemporary Security Policy* 19, no. 1 (1998): 23–54.

Krebs, Ronald R, and Aaron Rapport. "International relations and the psychology of time horizons." *International Studies Quarterly* 56, no. 3 (2012): 530–543.

Kreps, Sarah E. "The institutional design of arms control agreements." *Foreign Policy Analysis* 14, no. 1 (2018): 127–147.

Kreps, Sarah E, Elizabeth N Saunders, and Kenneth A Schultz. "The Ratification Premium: Hawks, Doves, and Arms Control." *World Politics* 70, no. 4 (2018): 479–514.

Kreps, Sarah Elizabeth, and Anthony Clark Arend. "Why States Follow the Rules: Toward a Positional Theory of Adherence to International Legal Regimes." *Duke J. Comp. & Int'l L.* 16 (2006): 331.

Krishnan, Armin. *Killer robots: legality and ethicality of autonomous weapons*. Routledge, 2016.

Kristensen, Hans M. "Global Nuclear Arsenals, 1990–2018." In *Nuclear Safeguards, Security, and Nonproliferation*, 3–35. Elsevier, 2019.

Kristensen, Hans M, and Robert S Norris. "Chinese nuclear forces, 2018." *Bulletin of the Atomic Scientists* 74, no. 4 (2018): 289–295.

———. "Global nuclear weapons inventories, 1945–2013." *Bulletin of the Atomic Scientists* 69, no. 5 (2013): 75–81.

Kroenig, Matthew. "The return to the pressure track: The trump administration and the Iran nuclear deal." *Diplomacy & Statecraft* 29, no. 1 (2018): 94–104.

Kroenig, Matthew, and Tristan Volpe. "3-D printing the bomb? The nuclear nonproliferation challenge." *The Washington Quarterly* 38, no. 3 (2015): 7–19.

Kucik, Jeffrey, and Eric Reinhardt. "Does flexibility promote cooperation? An application to the global trade regime." *International Organization* 62, no. 3 (2008): 477–505.

Kutt, Moritz, Malte Gottsche, and Alex Glaser. "Disarmament Hacking 2.0: Toward a Trusted, Open-Hardware Computing Platform for Nuclear Warhead Verification." In *57th Annual Meeting of the Institute for Nuclear Materials Management, Atlanta, GA*. 2016.

Kydd, Andrew. "Arms races and arms control: Modeling the hawk perspective." *American Journal of Political Science*, 2000, 228–244.

Lall, Ranjit. "Beyond institutional design: Explaining the performance of international organizations." *International Organization* 71, no. 2 (2017): 245–280.

Larkin, Bruce. *Nuclear Designs: Great Britain, France and China in the global governance of nuclear arms*. Routledge, 2018.

Leeds, Brett Ashley. "Domestic political institutions, credible commitments, and international cooperation." *American Journal of Political Science*, 1999, 979–1002.

Leeds, Brett Ashley, and Burcu Savun. "Terminating alliances: Why do states abrogate agreements?" *The Journal of Politics* 69, no. 4 (2007): 1118–1132.

Lentzos, Filippa, and Nikolas Rose. "Governing insecurity: contingency planning, protection, resilience." *Economy and Society* 38, no. 2 (2009): 230–254.

Lewis, John. "The case for regulating fully autonomous weapons." *Yale LJ* 124 (2014): 1309.

Lieber, Keir A, and Daryl G Press. "The new era of counterforce: Technological change and the future of nuclear deterrence." *International Security* 41, no. 4 (2017): 9–49.

Lin-Greenberg, Erik. "Game of Drones: The Effect of Remote Warfighting Technology on Conflict Escalation (Evidence from Wargames)." *Available at SSRN 3288988*, 2018.

Lipson, Charles. "International cooperation in economic and security affairs." *World Politics* 37, no. 1 (1984): 1–23.

———. "Why are some international agreements informal?" *International Organization* 45, no. 4 (1991): 495–538.

Lupu, Yonatan. "The informative power of treaty commitment: using the spatial model to address selection effects." *American Journal of Political Science* 57, no. 4 (2013): 912–925.

Lutmar, Carmela, Cristiane L Carneiro, and Sara McLaughlin Mitchell. *Formal commitments and states' interests: Compliance in international relations*. Taylor & Francis, 2016.

Mansfield, Edward D, and Helen V Milner. *Votes, vetoes, and the political economy of international trade agreements*. Princeton University Press, 2012.

Mansfield, Edward D, Helen V Milner, and B Peter Rosendorff. "Why democracies cooperate more: Electoral control and international trade agreements." *International Organization* 56, no. 3 (2002): 477–513.

Manzo, Vince. *Nuclear Arms Control Without a Treaty? Risks and Options After New START*. Technical report. Center for Naval Analyses, 2019.

March, James G, and Johan P Olsen. "The institutional dynamics of international political orders." *International Organization* 52, no. 4 (1998): 943–969.

Marshall, Monty G, Keith Jaggers, and Ted Robert Gurr. "Polity IV project: Dataset users manual." *University of Maryland*, 2002.

Martin, Lisa L. *Democratic commitments: Legislatures and international cooperation*. Princeton University Press Princeton, 2000.

Mastanduno, Michael. *Economic containment: CoCom and the politics of East-West trade*. Cornell University Press, 1992.

Matanock, Aila M. *Electing Peace: From Civil Conflict to Political Participation*. Cambridge University Press, 2017.

Mattes, Michaela, and Burcu Savun. "Fostering peace after civil war: Commitment problems and agreement design." *International Studies Quarterly* 53, no. 3 (2009): 737–759.

Mattes, Michaela, and Jessica LP Weeks. "Hawks, Doves, and Peace: An Experimental Approach." *American Journal of Political Science* 63, no. 1 (2019): 53–66.

Mattli, Walter, and Ngaire Woods. *The politics of global regulation*. Princeton University Press, 2009.

Mearsheimer, John J. "The false promise of international institutions." *International Security* 19, no. 3 (1994): 5–49.

Meyer, Paul. "Cyber-security through arms control: an approach to international co-operation." *the RUSI Journal* 156, no. 2 (2011): 22–27.

Meyer, Stephen M. "Verification and risk in arms control." *International Security* 8, no. 4 (1984): 111–126.

Miller, Steven E. "Politics over promise: Domestic impediments to arms control." *International Security* 8, no. 4 (1984): 67–90.

Milner, Helen. "International theories of cooperation among nations: Strengths and weaknesses." *World Politics* 44, no. 3 (1992): 466–496.

Milner, Helen V, and B Peter Rosendorff. "Democratic politics and international trade negotiations: Elections and divided government as constraints on trade liberalization." *Journal of Conflict resolution* 41, no. 1 (1997): 117–146.

Mitchell, Ronald B. "Problem structure, institutional design, and the relative effectiveness of international environmental agreements." *Global Environmental Politics* 6, no. 3 (2006): 72–89.

———. "Regime design matters: intentional oil pollution and treaty compliance." *International Organization* 48, no. 3 (1994): 425–458.

Moravcsik, Andrew. "Taking preferences seriously: A liberal theory of international politics." *International Organization* 51, no. 4 (1997): 513–553.

Morrow, James D. "Alliances and asymmetry: An alternative to the capability aggregation model of alliances." *American journal of political science*, 1991, 904–933.

Muller, Harald. "Compliance politics: A critical analysis of multilateral arms control treaty enforcement." *The Nonproliferation Review* 7, no. 2 (2000): 77–90.

Nash Jr, John F. "The bargaining problem." *Econometrica: Journal of the Econometric Society*, 1950, 155–162.

Nephew, Richard. "Triggers, Redlines, and the Fate of the Iran Nuclear Accord." *Arms Control Today* 47, no. 10 (2017): 21–25.

Nye, Joseph S. "Arms control after the cold war." *Foreign Affairs* 68, no. 5 (1989): 42–64.

———. *The regime complex for managing global cyber activities*. Centre for International Governance Innovation / Catham House, 2014.

Olson, Mancur. *The Logic of Collective Action*. Harvard University Press, 1965.

Ovodenko, Alexander, and Robert O Keohane. "Institutional diffusion in international environmental affairs." *International Affairs* 88, no. 3 (2012): 523–541.

Oye, Kenneth A. "Explaining cooperation under anarchy: Hypotheses and strategies." *World Politics* 38, no. 1 (1985): 1–24.

Pelc, Krzysztof J. "Seeking escape: The use of escape clauses in international trade agreements." *International Studies Quarterly* 53, no. 2 (2009): 349–368.

Philippe, Sebastien, Robert J Goldston, Alexander Glaser, and Francesco d'Errico. "A physical zero-knowledge object-comparison system for nuclear warhead verification." *Nature Communications* 7 (2016): 12890.

Platt, Alan. *The Politics of Arms Control and the Strategic Balance*. Technical report. RAND Corporation, Santa Monica CA, 1982.

Possony, Stefan T. "Peace enforcement." *The Yale Law Journal* 55, no. 5 (1946): 910–949.

Potter, William C. "Disarmament diplomacy and the nuclear ban treaty." *Survival* 59, no. 4 (2017): 75–108.

———. "Verification and arms control," 1985.

Price, Richard. "A genealogy of the chemical weapons taboo." *International Organization* 49, no. 1 (1995): 73–103.

Putnam, Robert D. "Diplomacy and domestic politics: the logic of two-level games." *International organization* 42, no. 3 (1988): 427–460.

Ranger, Robin. *Arms and Politics, 1958-1978: Arms Control in a Changing Political Context*. Macmillan of Canada, 1979.

Raustiala, Kal. "Form and substance in international agreements." *American Journal of International Law* 99, no. 3 (2005): 581–614.

Reddie, Andrew. "Hypersonic Hysteria: Examining the Hypersonic Hammer." *Center for Strategic and International Studies*, 2018.

Reif, Kingston. "After the INF Treaty, What Is Next?" *Arms Control Today* 49, no. 1 (2019): 26–29.

Roberts, Brad. "From nonproliferation to antiproliferation." *International Security* 18, no. 1 (1993): 139–173.

Rosendorff, B Peter, and Helen V Milner. "The optimal design of international trade institutions: Uncertainty and escape." *International Organization* 55, no. 4 (2001): 829–857.

Ruggie, John Gerard. "International responses to technology: concepts and trends." *International organization* 29, no. 3 (1975): 557–583.

Russell, Stuart, S Hauert, R Altman, and M Veloso. "Ethics of artificial intelligence." *Nature* 521, no. 7553 (2015): 415–416.

Schear, James A. "Arms Control Treaty Compliance: Buildup to a Breakdown?" *International Security* 10, no. 2 (1985): 141–182.

Schelling, Thomas C. "Reciprocal measures for arms stabilization." *Daedalus* 134, no. 4 (2005): 101–117.

———. *The strategy of conflict*. Harvard University Press, 1960.

———. "The strategy of conflict. Prospectus for a reorientation of game theory." *Journal of Conflict Resolution* 2, no. 3 (1958): 203–264.

———. "What went wrong with arms control?" *Foreign Affairs* 64, no. 2 (1985): 219–233.

Schelling, Thomas C, and Morton H Halperin. "Strategy and Arms Control." *Twentieth Century Fund*, 1961.

Scherer, Matthew U. "Regulating artificial intelligence systems: Risks, challenges, competencies, and strategies." *Harv. JL & Tech.* 29 (2015): 353.

Schutz, Torben. "Technology and Strategy: Hypersonic Weapon Systems Will Decrease Global Strategic Stability-and Current Control Regimes Won't Do," 2019.

Shanks, Cheryl, Harold K Jacobson, and Jeffrey H Kaplan. "Inertia and change in the constellation of international governmental organizations, 1981–1992." *International organization* 50, no. 4 (1996): 593–627.

Sharot, Tali, Alison M Riccardi, Candace M Raio, and Elizabeth A Phelps. "Neural mechanisms mediating optimism bias." *Nature* 450, no. 7166 (2007): 102.

Sick, Gary G. "Iran After the Deal." *Foreign Affairs*, 2015.

Simmons, Beth A. "International law and state behavior: Commitment and compliance in international monetary affairs." *American Political Science Review* 94, no. 4 (2000): 819–835.

Simmons, Beth A. "Treaty compliance and violation." *Annual Review of Political Science* 13 (2010): 273–296.

Simmons, Beth A, and Daniel J Hopkins. "The constraining power of international treaties: Theory and methods." *American Political Science Review* 99, no. 4 (2005): 623–631.

Singh, Sonali, and Christopher R Way. "The correlates of nuclear proliferation: A quantitative test." *Journal of Conflict Resolution* 48, no. 6 (2004): 859–885.

Slantchev, Branislav L. "Politicians, the media, and domestic audience costs." *International Studies Quarterly* 50, no. 2 (2006): 445–477.

Snidal, Duncan. "Coordination versus prisoners' dilemma: Implications for international cooperation and regimes." *American Political Science Review* 79, no. 4 (1985): 923–942.

———. "Relative gains and the pattern of international cooperation." *American Political Science Review* 85, no. 3 (1991): 701–726.

Snyder, Ryan, Benoit Pelopidas, Keir A Lieber, and Daryl G Press. "Correspondence: New Era or New Error? Technology and the Future of Deterrence." *International Security* 43, no. 3 (2019): 190–193.

Taddeo, Mariarosaria, and Luciano Floridi. "Regulate artificial intelligence to avert cyber arms race," 2018.

Tannenwald, Nina. "Stigmatizing the bomb: Origins of the nuclear taboo." *International Security* 29, no. 4 (2005): 5–49.

———. "The nuclear taboo: The United States and the normative basis of nuclear non-use." *International Organization* 53, no. 3 (1999): 433–468.

Taylor, Michael. *The possibility of cooperation*. Cambridge University Press, 1987.

Tertrais, Bruno. "Iran: An experiment in strategic risk-taking." *Survival* 57, no. 5 (2015): 67–73.

Thompson, Alexander, and Daniel Verdier. "Multilateralism, bilateralism, and regime design." *International Studies Quarterly* 58, no. 1 (2014): 15–28.

Thompson, Christopher Glen, Rae Seon Kim, Ariel M Aloe, and Betsy Jane Becker. "Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results." *Basic and Applied Social Psychology* 39, no. 2 (2017): 81–90.

Tomz, Michael. *Democratic default: Domestic audiences and compliance with international agreements*. Stanford University Press, 2002.

———. *Reputation and international cooperation: sovereign debt across three centuries*. Princeton University Press, 2012.

Trachtenberg, Marc. "The Past and Future of Arms Control." *Daedalus*, 1991, 203–216.

Tsipis, Kosta, David W Hafemeister, and Penny Janeway. *Arms control verification: The technologies that make it possible*. Pergamon Books Inc., Elmsford, NY, 1986.

Vabulas, Felicity, and Duncan Snidal. "Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements." *The Review of International Organizations* 8, no. 2 (1990): 193–220.

Valentino, Benjamin, Paul Huth, and Sarah Croco. "Covenants Without the Sword International Law and the Protection of Civilians in Times of War." *World Politics* 58, no. 3 (2006): 339–377.

Van Evera, Stephen. "Offense, defense, and the causes of war." *International Security* 22, no. 4 (1998): 5–43.

———. "The cult of the offensive and the origins of the First World War." *International Security* 9, no. 1 (1984): 58–107.

Vaynman, Jane Eugenia. "Enemies in Agreement: Domestic Politics, Uncertainty, and Cooperation between Adversaries." PhD diss., Cornell University, 2014.

Vineis, Paolo, and Anthony J McMichael. "Bias and confounding in molecular epidemiological studies: special considerations." *Carcinogenesis* 19, no. 12 (1998): 2063–2067.

Von Stein, Jana. "Do treaties constrain or screen? Selection bias and treaty compliance." *American Political Science Review* 99, no. 4 (2005): 611–622.

Vreeland, James Raymond. "Political institutions and human rights: Why dictatorships enter into the United Nations Convention Against Torture." *International Organization* 62, no. 1 (2008): 65–101.

Waever, O. "Securitization and desecuritization." In *On security*. Columbia University Press, 1995.

Wallander, Celeste A. "Institutional assets and adaptability: NATO after the Cold War." *International Organization* 54, no. 4 (2000): 705–735.

Walter, Barbara F. "Designing transitions from civil war: Demobilization, democratization, and commitments to peace." *International Security* 24, no. 1 (1999): 127–155.

Waltz, Kenneth N. *Theory of International Politics*. Waveland Press, 1979.

———. "Why Iran should get the bomb: Nuclear balancing would mean stability." *Foreign Affairs* 91 (2012).

Weber, Katja. "Hierarchy amidst anarchy: A transaction costs approach to international security cooperation." *International Studies Quarterly* 41, no. 2 (1997): 321–340.

Weber, Steve. *Cooperation and discord in US-Soviet arms control*. Vol. 166. Princeton University Press, 1992.

Weeks, Jessica L. "Autocratic audience costs: Regime type and signaling resolve." *International Organization* 62, no. 1 (2008): 35–64.

———. "Autocratic audience costs: Regime type and signaling resolve." *International Organization* 62, no. 1 (2008): 35–64.

———. "Strongmen and straw men: Authoritarian regimes and the initiation of international conflict." *American Political Science Review* 106, no. 2 (2012): 326–347.

Weiss, Jessica Chen. "Authoritarian signaling, mass audiences, and nationalist protest in China." *International Organization* 67, no. 1 (2013): 1–35.

Werner, Suzanne, and Amy Yuen. "Making and keeping peace." *International Organization* 59, no. 2 (2005): 261–292.

White, Halbert, et al. "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity." *Econometrica* 48, no. 4 (1980): 817–838.

Williams, Heather. "A nuclear babel: narratives around the Treaty on the Prohibition of Nuclear Weapons." *The Nonproliferation Review* 25, nos. 1-2 (2018): 51–63.

Williamson Jr, Richard L. "Hard law, Soft law, and Non-Law in multilateral arms control: some compliance hypotheses." *Chi. J. Int'l L.* 4 (2003): 59.

Woolf, Amy F. "Monitoring and Verification in Arms Control." *Congressional Research Service* 41201 (2011).

Young, Oran R. *Compliance & public authority: A theory with international applications*. RFF Press, 2013.

———. *International cooperation: Building regimes for natural resources and the environment*. Cornell University Press, 1989.

Zeileis, Achim. "Object-oriented computation of sandwich estimators." *Journal of Statistical Software* 16, no. 9 (2006).