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Do Arms Control Treaties Work? Assessing the Effectiveness of the Nuclear Nonproliferation Treaty[1]

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How do international arms control treaties influence state policies? This article investigates this question by analyzing the efficacy of the nuclear Nonproliferation Treaty (NPT). Despite fierce debate over the last several decades, scholars still lack a full understanding of whether or not the treaty "works." This debate persists, in part, because existing studies suffer from a key limitation: they are not designed to infer a causal connection between NPT membership and nuclear proliferation. Prior research cannot determine whether membership in the treaty restrains states from developing nuclear weapons or simply reflects existing preferences. To address this limitation, this article accounts for selection effects by using a measure of states' ex ante treaty commitment preferences. Our analysis of nuclear proliferation from 1970 to 2000 provides evidence that the NPT has played a key role in curbing the spread of nuclear weapons. Even after accounting for strategic selection into the treaty, NPT ratification is robustly associated with a lower likelihood of pursuing nuclear weapons. Our results not only matter for debates over the NPT and nonproliferation but also have broad implications for the study of how international institutions affect international politics.

Introduction

Perhaps the earliest example of arms control dates back to the eighth century BCE, when two cities in ancient Greece, Chalcis and Eretria, agreed to ban the use of "missiles" (Connor 1988, 19). In the centuries that followed, international actors used formal agreements to restrain the proliferation or use of poison bullets, the crossbow, naval warships, anti-ballistic missiles, biological weapons, chemical weapons, anti-personnel land mines, and other military technologies. Although arms control treaties were particularly common during the Cold War, they are by no means relics of a bygone era: today, some policymakers support creating international treaties to control emerging technologies, particularly drones and cyberwarfare capabilities.

These agreements exist, in part, because some believe that they help to thwart potentially dangerous arms races. Yet many scholars argue just the opposite: that arms control treaties are ineffective (for example, Downs, Rocke, and Barsoom 1996). Arms control also has its fair share of critics in the policy community, some of whom see it as "unreliable, worthless, unsuccessful, [and] possibly even counterproductive" (Miller 2003, 16).

Do arms control treaties work? More specifically, do such agreements constrain state policies and reduce the risk of arms proliferation, or do the commitments embodied in them merely reflect preexisting preferences? Our understanding of how treaties influence world politics has increased tremendously in recent years. Research examines the effects of international institutions governing human rights, the environment, humanitarian law, and economic relations (for example, Simmons 2000, 2010; Sikkink 2011; Lutz and Sikkink 2000; von Stein 2005, 2008, forthcoming; Hill 2010; Ritter and Wolford 2012; Conrad and Ritter 2013; Lupu 2013a, 2015). However, far fewer studies (for example, Leeds 2003; Mattes and Vonnahme 2010; Mitchell and Hensel 2007; Prorok and Huth 2015) systematically examine the effects of security institutions in general and arms control agreements in particular.

We focus on a key arms control treaty: the nuclear Nonproliferation Treaty (NPT). The NPT requires most countries to refrain from building nuclear weapons while allowing five states to maintain nuclear arsenals.[2] We ask the following research question: has the NPT limited the spread of nuclear weapons? Scholars have fiercely debated this issue for more than forty years, but we still do not fully understand the effects of the NPT. Some argue that the treaty has substantially curbed the spread of nuclear weapons (for example, Nye 1981), while others suggest that it has done little more than "screen" participants (for example, Betts 1999).[3] Which of these views is correct?

Existing literature does not provide a clear answer. Although many studies examine the correlation between NPT ratification and nuclear proliferation (for example,

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[2]The permanent five members of the UN Security Council are permitted to possess nuclear weapons because they conducted successful nuclear tests prior to January 1, 1967.

[3]Treaties (including the NPT) may simultaneously constrain and screen state parties. Moreover, international agreements may "work" even if they only screen participants. In that case, whether or not a country ratifies a treaty provides others with useful information about its intentions. See Simmons (2009,12–14) and Morrow (2014,22–59).

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Jo and Gartzke 2007; Fuhrmann 2012; Miller 2014), these studies are not designed to reasonably infer a causal connection because they do not account for the factors that motivate states to ratify the treaty. States "self-select" into the NPT, meaning that whether they enter the agreement depends partly on their treaty commitment preferences (Downs, Rocke, and Barsoom 1996; von Stein 2005). Without accounting for this, scholars risk inferring a relationship between treaty commitment and compliance that is an artifact of underlying preferences.

This study addresses this limitation. We analyze the relationship between NPT ratification and nuclear proliferation using a technique that estimates states' treaty commitment preferences and, based on these, states' ex ante probability of ratifying the NPT (Lupu 2013b). Using these estimates allows us to make inferences about the effects of the NPT while weakening the assumptions needed to do so. Yet, as with any other observational study, our inferences nonetheless require important assumptions.

Our analysis of nuclear proliferation from 1970 to 2000 provides evidence that the NPT has played a key role in curbing the spread of nuclear weapons. Even after accounting for strategic selection into the treaty, NPT ratification is robustly associated with a lower likelihood of nuclear proliferation. We therefore provide evidence of a causal relationship between NPT membership and the spread of nuclear weapons. Existing work requires strong assumptions to infer that the NPT has a causal effect on proliferation; our research significantly weakens these assumptions. Our results, then, may help resolve a longstanding debate about the efficacy of the NPT.

In addition, our findings speak to broader scholarly debates about whether (and how) security agreements affect international politics. Many argue that international institutions do not independently affect state behavior (for example, Mearsheimer 1994). Our study suggests that this view may be too pessimistic. To be sure, international cooperation on security issues can be difficult. Yet we provide new evidence that security-related treaties restrain states from pursuing policies that they might otherwise prefer. Combined with insights from earlier studies (for example, Leeds 2003; Fortna 2003), this suggests that international institutions may play a greater role in promoting peace than many scholars believe.

Finally, our analysis has important policy implications. Few issues are more consequential than the proliferation of nuclear weapons. US President Barack Obama has called the threat of nuclear weapons "the greatest danger to the American people."[4] We therefore need to better understand how to reduce the risk of nuclear proliferation. Our results indicate that the NPT has been effective in reducing this risk. It supports claims that the NPT plays a crucial role in nuclear proliferation dynamics. We hope our findings will contribute to policy debates regarding how to design, implement, and assess the effectiveness of other arms control agreements, including those covering small arms, chemical weapons, and biological weapons.

We proceed by explaining the existing views on the efficacy of the NPT in greater detail and identifying testable hypotheses. The subsequent section discusses our research design, taking care to explain our data and our approach to dealing with the non-random assignment of NPT membership. We then discuss our empirical findings and highlight several robustness tests. Conclusions and implications follow.

[4]Obama made this statement during his 2010 State of the Union Address: https://www.whitehouse.gov/the-press-office/remarks-president-state-union-address.

The (F)utility of the NPT

The NPT numbers among the most widely discussed treaties in scholarship.[5] Arguments about NPT effectiveness fall into two main camps. One is optimistic about the treaty's impact on world politics, while the other is less sanguine.

NPT Optimists

Many scholars argue that the NPT restrains nuclear proliferation (see Nye 1981; Sagan 1996; Rublee 2009; Dai 2002; Coe and Vaynman 2015). According to this view, many countries that ultimately refrained from building the bomb would have been more likely to proliferate in the absence of an NPT commitment.

Advocates point to several reasons why the NPT reduces the risk of nuclear proliferation. A particularly common argument draws on broader ideas about how international institutions can facilitate international cooperation. Based on this perspective, the NPT regime facilitates the exchange of information; reduces uncertainty about others' behavior, capabilities, and intentions; and increases the costs of cheating, all of which should bring states into compliance (see Dai 2002).[6]

When states join the NPT, they pledge not to build or otherwise acquire nuclear weapons. Member states must accept fairly stringent verification measures, including allowing inspectors from the International Atomic Energy Agency (IAEA) to visit their nuclear facilities and verify that materials have not been diverted for military purposes. According to institutionalist theory, this deters NPT members from shirking their commitments. In contrast, countries that remain outside the NPT generally have greater confidence that they can keep weapons-related activities secret.

Once transgressions are detected, enforcement falls mostly to individual countries. It is not uncommon for states invested in nonproliferation to seriously consider launching preventive strikes against states seeking to build the bomb. In a handful of cases—most notably, Israel's attacks against Iraq (1981) and Syria (2007)—countries actually carried out "bolt from the blue" strikes against nuclear facilities (see Fuhrmann and Kreps 2010). States that do not comply with their NPT commitments could also face economic sanctions that lead to a loss in foreign investment (Solingen 2007). Material costs aside, the international community may label NPT violators "irresponsible," which would reduce their standing in the international system (Rublee 2009).[7]

Domestic politics might also aid the treaty's effectiveness. International agreements can empower domestic actors who have a vested interest in compliance. The NPT may enable operators of nuclear power plants to pressure leaders to remain in compliance, so a country's civilian nuclear program is not disrupted (Sagan 2011, 238). Domestic civil society actors can also mobilize and pressure the government to

[5]According to JSTOR, as of February 19, 2016, 7,093 published books and articles contain the phrases "non-proliferation treaty" or "nonproliferation treaty."

[6]Not all optimists focus on these mechanisms. Coe and Vaynman (2015), for example, emphasize the role of superpower collusion in making the NPT-backed regime stable.

[7]For a fuller discussion of how norms might contribute to nonproliferation, see Rublee(2009) and Tannenwald (2007).

refrain from violating the NPT. In Japan, for instance, NPT membership increased the efficacy of anti-nuclear NGOs domestically by granting them additional platforms and increased legitimacy (Rublee 2009, 79). Along similar lines, treaty commitment strengthens the ability of *transnational* actors to pressure the government to improve its practices and impose costs on the government when it violates international norms (for example, Simmons 2009; Linos 2011). In the NPT case, nonstate actors often use conferences associated with the treaty as "focal points" to lobby governments and protest pro-nuclear policies (Rublee 2009, 38).

These international and domestic mechanisms together "lock in" a nonnuclear posture after countries make an NPT commitment, according to NPT optimists. It is always possible, of course, for an NPT member to revisit its nuclear policy, but this option is often viewed as unattractive, even if new security threats arise. Australia, for instance, ratified the NPT in 1973. The following year, India conducted its first nuclear test, leaving some officials in Canberra feeling threatened. Rather than exploring the nuclear option in response to a threat—as it did prior to ratifying the NPT—Australia maintained the status quo, in part because ratifying the NPT increased the costs of a policy reversal. Thus, as Jim Walsh (1997, 13) argues in his history of Australia's nuclear program, "ratification of the NPT marked a turning point, a decisive step away from nuclear weapons."

This logic leads to the following hypothesis:

NPT Optimist Hypothesis: *Ratification of the NPT reduces the likelihood of nuclear proliferation.*

NPT Pessimists

An alternative view suggests that the NPT has done relatively little to curb the spread of nuclear weapons (for example, Mearsheimer 1993; Betts 1999; Hymans 2006; Solingen 2007; Fuhrmann 2012). Proponents of this perspective make two related arguments.

First, drawing on the logic of strategic selection into treaties (Downs, Rocke, and Barsoom 1996), pessimists argue that the NPT is an effect of nonproliferation, not a cause of it (Betts 1999, 69). States may join the NPT because they have little or no intention of pursuing nuclear weapons (their preferences are aligned ex ante with the treaty's requirements). To the extent that this is the case, the treaty screens for proliferation rather than constrains it.[8] Thus, even if there is a correlation between NPT membership and restraint from the pursuit of nuclear weapons, these variables may not be causally connected. In this view, we observe a relationship between the NPT and nonproliferation simply because states are more likely to ratify the treaty when they have already decided not to build nuclear weapons.

A second argument emphasizes the institutional weaknesses of the NPT. Based on this line of thinking, the NPT is little more than a "scrap of paper" that cannot constrain states when their national security is on the line. Pessimists argue that neither the prospect of detection by the IAEA nor the threat of punishment sufficiently deters determined proliferators (see especially Hymans 2006, 6–7). The IAEA's safeguards regime is relatively weak, according to NPT pessimists, and enforcement of NPT violations is lax and uneven. Some countries suffer military attacks or harsh economic sanctions when they violate the NPT, as previously noted, but others escape with little more than a slap on the wrist. The deterrent effect of the NPT substantially weakens if countries believe that they will not face significant punishment in the event that the IAEA detects an illicit nuclear program.

Scholars in this camp sometimes suggest that domestic factors influence nonproliferation policy (see especially Solingen 2007). However, they are generally skeptical that domestic politics can increase the constraining power of the NPT. To be sure, few NPT pessimists take the domestic mechanisms highlighted above seriously.

To support these claims, pessimists point out that joining the treaty does not always solidify a state's nonnuclear posture. Iran, Iraq, Libya, North Korea, Romania, South Korea, and possibly other NPT members violated their treaty commitments (Fuhrmann 2012, chapter 9). This evidence shows, pessimists argue, that the treaty has significant limitations.

The following hypothesis emerges from the preceding arguments:

NPT Pessimist Hypothesis: *There is no relationship between NPT membership and nuclear proliferation once one accounts for selection into the treaty.*

The Empirical Evidence: No Consensus Yet

The existing literature provides mixed empirical evidence that supports both of the views articulated above but does not allow us to clearly adjudicate among these theories. Detailed case studies of nuclear decision making in Japan, West Germany, South Korea, Sweden, and other countries suggest that the NPT contributed to nuclear restraint (for example, Rublee 2009). But others who look at many of the same cases conclude that the NPT contributed little to nuclear restraint. Betts (1999, 69) states that there is not a single country that would have pursued nuclear weapons but for its commitment to the NPT (see also Hymans 2006; Solingen 2007).

The findings about the NPT in the extant quantitative literature are likewise mixed. As shown in Table 1, six of the thirteen studies (about 46%) that include the NPT in at least one statistical model report a negative correlation between the treaty and nuclear proliferation. The other 54% report mixed results or no significant relationship. Five of eighteen recently published studies exclude the NPT altogether in part because of concerns about the data generation process.

Existing scholarship has contributed to knowledge about the NPT in many ways. Yet studies carried out to date share a key limitation: scholars have yet to design a study to test whether the NPT has had a causal impact on state behavior (see Fuhrmann 2012, 245–6). NPT pessimists and others recognize that states consider whether they will build nuclear weapons in the future when deciding whether to join the NPT. Yet, although causal inference is especially difficult in this context because states select into NPT membership for clearly non-random reasons, no existing study has even attempted to account for the nonrandom assignment of treaty membership. This is not a simple problem to address, but we cannot understand the causal effect of the NPT without properly accounting for the process by which states are assigned to the "treatment" or "control" group. Statistical studies published to date have generally been designed to broadly identify the

[8] On the distinction between screening and constraining, see von Stein (2005).

Table 1. Existing findings on the NPT and nuclear proliferation

	Excluded from main models	*No significant effect*	*Mixed results*	*Negative effect*
Bell (forthcoming)		X		
Bleek (2010)				X
Bleek and Lorber (2014)				X
Brown and Kaplow (2014)			X	
Fuhrmann (2009)				X
Fuhrmann (2012)			X	
Fuhrmann and Berejikian (2012)		X		
Fuhrmann and Horowitz (2015)			X	
Horowitz (2010)	X			
Horowitz and Narang (2014)				X
Jo and Gartzke (2007)				X
Kroenig (2009)	X			
Meyer (1984)			X	
Miller (2014)				X
Montgomery (2013)			X	
Reiter (2014)	X			
Singh and Way (2004)	X			
Way and Weeks (2014)	X			

correlates or predictors of proliferation (Singh and Way 2004; Jo and Gartzke 2007) or to test arguments about nuclear proliferation that are unrelated to the NPT (for example, Miller 2014; Fuhrmann and Horowitz 2015). As a result, these studies aim to control for variables that might predict proliferation rather than factors that might confound the relationship between NPT ratification and proliferation.

Existing case study research usefully unpacks the decision-making process in particular cases, but it tends to focus on a small number of cases that may be especially interesting but may not represent the population of cases. Although it is useful to draw conclusions about these cases, we are also interested in broader inferences.[9]

Research Design

Our study addresses the empirical limitations of prior research. To understand the relationship between NPT membership and nuclear proliferation, we use a procedure that attempts to account for states' self-selection into the NPT. Our empirical tests rely on a sample of country-year observations that is more appropriate for evaluating the treaty's effect on nuclear proliferation given that states select into the treaty.

Estimating the effects of treaty commitments is known to be difficult. Governments select the treaties they join in part based on their interests and the extent to which they expect to conform their behavior to the treaties' requirements. Preferences drive a significant part of the difference between treaty members and non-members: members may be significantly more likely to join a treaty simply because they prefer the policy choices embodied in it (Downs, Rocke, and Barsoom 1996). States that join a treaty may not be comparable to states that refrain from doing so. No methodology, quantitative or qualitative, can allow us to infer causation based on these observational data without assumptions. We design our analysis to weaken these assumptions as much as possible. We must, of course, be somewhat circumspect about our results because any causal inference from observational data is subject to assumptions.

Simmons and Hopkins (2005) propose to address this problem by using a propensity-score matching approach. This approach estimates each state's probability of treaty ratification based on factors that predict ratification and then matches treaty members to treaty non-members based on this probability. The result is a sample balanced on the probability of treaty ratification (or treatment), with respect to which we might consider selection as having been randomly assigned. This approach creates covariate balance and weakens distributional assumptions.

Matching is nonetheless sensitive to omitted variable bias. If an unobservable (or unmeasured) factor affects treaty commitment decisions and is not included in the matching model, this can bias inferences in a manner analogous to omitted variable bias in a standard regression context. Lupu (2013b) argues that treaty commitment preferences constitute a key latent factor that affects treaty commitment decisions. As Downs, Rocke, and Barsoom (1996) and others have noted, without controlling for underlying preferences, we cannot distinguish whether compliance with international institutions results from these preferences or whether commitment to an institution affects the probability of compliance. Lupu (2013b) proposes a methodology to estimate these preferences and to estimate each state's probability of joining a given treaty. This methodology estimates the ideal points of states with respect to universal treaties by using the W-NOMINATE algorithm (Poole and Rosenthal 1997). In this measurement model, the options of committing and not committing to a treaty are represented by points in an n-dimensional policy space. We assume each state decides whether or not to commit to a treaty by, among other factors, considering the distance between these points and its ideal point in this space (the extent to which the treaty is close to the state's preferred policy outcome). The probability of a particular state ratifying a particular treaty decreases as the distance between the state's ideal point and the treaty increases in the preference space.

We follow Lupu (2013b) by using a three-stage research design. First, we use W-NOMINATE to estimate each state's probability of joining the NPT on an annual basis.[10] This measurement strategy estimates these probabilities based on states' revealed treaty commitment preferences. We do so by using a data set of membership in approximately 280 universal treaties. This data set includes all of the universal treaties included in the United Nations Treaty Collection (UNTC). The treaties cover a broad range of substantive areas, including arms control, immunity, human rights, transportation, the environment, and communications.[11] The data are coded "1" for country-years that have ratified a treaty and "0" otherwise. Although it may not be immediately obvious why treaties covering other policy areas can help us to predict NPT ratification, this is the case empirically. We should note that the sole purpose of this stage in the research design is to estimate NPT commitment probabilities as accurately as possible. As Lupu (forthcoming) shows, including treaties that cover multiple policy areas improves model fit

[9]For example, many qualitative studies analyze how the NPT affected decision making in Japan and West Germany. These are very important cases because these countries were on the front-lines during the Cold War. For the same reason, it is difficult to generalize from these cases.

[10]This is not an estimate of a general propensity to ratify treaties but an estimate of the propensity to ratify the NPT specifically.

[11]For further details, see Lupu (forthcoming).

and generates more accurate predictions with respect to the joining of individual treaties.[12] In other words, including non-arms control treaties in the model allows us to make more accurate predictions regarding NPT joining. Including the measure generated using this procedure in the models described below increases our ability to correctly predict NPT ratification by approximately 21%.

W-NOMINATE estimates the locations of states and treaties in a two-dimensional preference space.[13] The closer a treaty is to a state's ideal point, the more likely the state is to ratify the treaty. The probability that state i ratifies treaty j is calculated as follows:

$$P(Ratify)_{ij} = \frac{\exp[u_{ijr}]}{\exp[u_{ijr}] + \exp[u_{ijn}]}$$

where u_{ijr} is the deterministic component of the state's utility from ratifying the treaty, and u_{ijn} is the deterministic component of the state's utility from not ratifying the treaty (Poole and Rosenthal 1997). Thus, if two states are estimated to have similar probabilities of ratifying the NPT, this means the two states' ideal points are at similar distances from the NPT (although the ideal points may be at different locations). The results provide annual estimates of each country's probability of ratifying the NPT. These estimates begin in 1970, the first year in which the NPT was in force, and continue to 2007. In the tables and text below, we refer to this estimated probability of NPT ratification as *TREATY COMMITMENT PREFERENCES*.

In the second stage, we use the *TREATY COMMITMENT PREFERENCES* measure and other predictors of NPT joining to estimate each state's probability of NPT commitment and to match states to each other. We list the variables included in the matching model in Tables 2 and 3. We match NPT members to non-members using the nearest-neighbor algorithm provided by the MatchIt package in the R programming language. A country-year that has ratified the NPT is matched to another country-year that has not ratified the NPT if the two are estimated to have nearly the same probability of entering the treaty. This creates a matched pair that differs with respect to their NPT commitments but differs very little in terms of their probability of joining the NPT.

In our matched sample, NPT country-year observations are similar to non-NPT country-year observations when it comes to a host of important political, strategic, and economic variables. This increases our ability to make "apples-to-apples" comparisons when we evaluate the nuclear behavior of NPT members vis-à-vis non-members. As with any observational study, whether or not matching is used, we cannot rule out the possibility of omitted variable bias. Nonetheless, as Lupu (2013b) shows, including the treaty commitment preference estimates in the model significantly decreases the model's sensitivity to omitted variable bias, thus reducing significantly the strength of the assumptions needed to make causal inferences based on the results. We conduct a sensitivity analysis to test for this below.

[12]In addition, if individual treaties are not helpful in predicting NPT joining, the inclusion of such treaties in the W-NOMINATE model would nonetheless not bias our results.

[13]Lupu (forthcoming) analyzes the substantive interpretation of the preference space. He finds that economics, and particularly trade, is the clearest and most consistent predictor of the first dimension of treaty commitment preferences. As in many other contexts of ideal point estimation, the meaning of the second dimension changes over time.

The third stage uses the matched sample to estimate logit models that are designed to test our hypotheses. For this analysis, we create two dependent variables based on nuclear proliferation data provided by Bleek (2010). *PROGRAM* is coded "1" for all country-years that are either pursuing nuclear weapons or already possess nuclear weapons and "0" otherwise. For example, Israel is coded as "1" from the time it initiated a nuclear weapons program in the 1950s until our analysis ends in 2000. By contrast, *PURSUIT* is coded "1" for all observations in which states are pursuing nuclear weapons but do not yet possess them and "0" otherwise. *PURSUIT* is not meaningful for country-years with nuclear arsenals (a country cannot pursue nuclear weapons if it already has an arsenal). Thus, observations in which a state possesses nuclear weapons are coded as missing with respect to *PURSUIT*. For example, Israel is coded as missing after it obtained its first nuclear weapon in 1967. Although nuclear proliferation occurs infrequently, both dependent variables have enough variance in our matched sample for the purposes of conducting statistical analysis: *PURSUIT* is coded "1" in 7% of cases, while *PROGRAM* is coded "1" in 10% of cases.

NPT RATIFICATION is our main "treatment" variable. We code it "1" if a state has ratified the NPT as of a given year and "0" otherwise. In all of our models, we control for the probability of NPT commitment estimated by the W-NOMINATE procedure described above and a number of other variables. A rivalry with the United States or Soviet Union may affect a state's willingness to commit to the NPT and its interest in pursuing nuclear weapons. We control for this with the variable *US/USSR RIVAL*, which is based on data from Klein, Goertz, and Diehl (2006). More generally, involvement in international disputes may affect a state's incentives to build nuclear weapons. We address this by including two variables: *MIDS* and *ENDURING RIVALRY*. The former variable measures the five-year moving average of the number of militarized interstate disputes per year in which a state is involved, and the latter indicates whether a state is part of an enduring rivalry.[14] To control for the effects of "nuclear umbrellas," we include a dummy variable from Fuhrmann (2012) that indicates whether the country-year has a defense pact with the United States or Soviet Union.

More developed economies may be better able to invest the necessary resources to build nuclear weapons, so we control for the natural log of each state's GDP per capita. We also account for the number of nuclear cooperation agreements (NCAs), the treaties governments sign to authorize nuclear exports, because these agreements may affect NPT ratification and nuclear proliferation (Fuhrmann 2009, 2012). This variable controls for two closely related phenomena: that higher levels of foreign assistance raise the risk of proliferation and that states with larger civilian nuclear programs have a greater opportunity to proliferate. Regime type may affect both the institutional constraints that influence NPT ratification and those that influence proliferation, so we include the 21-point indicator of regime type from the Polity IV Project (Marshall and Jaggers 2002). The end of the Cold War preceded many commitments to the NPT and likely also affected many states' proliferation decisions. We control for this by using an indicator that we code "1" for all post-1991 years in the sample. In addition, the variable *YEAR* accounts for the fact that countries have been more likely to ratify the NPT over time.

[14]Both of these variables are taken from Singh and Way (2004).

Table 2. Balance statistics — pursuit

	Treatment Group Mean	*Control Group Mean*	*% Improvement in Balance*	*t-test Difference p-value*	*eQQ med*
PROPENSITY SCORE	0.64	0.63	94.26	0.18	0.013
US/USSR RIVALRY	0.12	0.11	60.25	0.36	0.000
TREATY COMMITMENT PREFERENCES	0.59	0.56	90.33	0.09	0.028
NUCLEAR COOPERATION AGREEMENTS	6.02	6.27	84.33	0.69	1.000
MIDS	0.59	0.58	92.13	0.79	0.000
GDP PER CAPITA(LOGGED)	7.98	8.03	77.97	0.36	0.110
SUPERPOWER ALLIANCE	0.26	0.26	94.85	0.78	0.000
POLITY	−3.45	−3.23	94.89	0.52	0.000
COLD WAR	0.10	0.10	99.18	0.87	0.000
ENDURING RIVALRY	0.34	0.33	93.15	0.76	0.000
LEADER REBEL EXPERIENCE	0.55	0.54	87.54	0.49	0.000
PERSONALIST REGIME	0.35	0.32	50.80	0.25	0.000
YEAR	1980	1980	93.29	0.19	0.000
n	829	829			

Notes. eQQ med is the median difference in the empirical quantile-quantile plot. An eQQ med of zero is ideal.

Table 3. Balance statistics — program

	Treatment Group Mean	*Control Group Mean*	*% Improvement in Balance*	*t-test Difference p-value*	*eQQ med*
PROPENSITY SCORE	0.64	0.63	93.92	0.17	0.016
US/USSR RIVALRY	0.13	0.11	51.20	0.27	0.000
TREATY COMMITMENT PREFERENCES	0.62	0.60	90.00	0.11	0.023
NUCLEAR COOPERATION AGREEMENTS	6.92	6.83	92.25	0.90	1.000
MIDS	0.64	0.66	94.23	0.75	0.000
GDP PER CAPITA(LOGGED)	8.06	8.08	89.32	0.72	0.093
SUPERPOWER ALLIANCE	0.25	0.24	92.28	0.66	0.000
POLITY	−2.57	−2.50	98.13	0.85	0.000
COLD WAR	0.12	0.12	99.58	0.94	0.000
ENDURING RIVALRY	0.38	0.38	95.56	0.77	0.000
LEADER REBEL EXPERIENCE	0.53	0.52	99.12	0.96	0.000
PERSONALIST REGIME	0.32	0.30	43.74	0.38	0.000
YEAR	1982	1981	93.90	0.28	0.000
n	884	884			

Notes. eQQ med is the median difference in the empirical quantile-quantile plot. An eQQ med of zero is ideal.

Recent research suggests that leaders who are former rebels (Fuhrmann and Horowitz 2015) and personalistic regimes (Way and Weeks 2014) are more likely to seek nuclear weapons. We therefore control for both of these variables in our models. Finally, to address temporal dependence, we include a measure of the number of years the country has not pursued nuclear weapons or had a nuclear weapons program (*TIME*), depending on the applicable dependent variable, as well as $TIME^2$ and $TIME^3$, as recommended by Carter and Signorino (2010).

Results

We begin by discussing the results from the matching stage. Tables 2 and 3 report the balance statistics. These statistics show that matching greatly reduces covariate imbalance, but some imbalance remains between the treatment and control group, which is why we use logit models to test the effects of the NPT on the matched samples. Figure 1 illustrates which country-years are included in the matched data set for *PURSUIT*. Countries shaded in darker gray appear in the matched data set in a larger number of years. Figure 2 shows a similar map when *PROGRAM* is the dependent variable.

The main results are displayed in Table 4. *NPT RATIFICATION* is negatively associated with pursuing nuclear weapons (Model 1) and having a nuclear weapons program (Model 2). The NPT therefore appears to reduce the risk of nuclear proliferation, on average, even after we account for strategic selection into the treaty. These findings are consistent with the NPT optimist hypothesis.

Statistical significance aside, *NPT RATIFICATION* is substantively important in shaping the probability of nuclear proliferation. Many states are ex ante very unlikely to build nuclear weapons—for example, Burkina Faso—often because they lack the security incentives and/or economic capabilities to do so. In cases with very low probabilities of proliferation ex ante, the NPT may do little to further lower such probabilities. We therefore consider how NPT ratification affects the probability of seeking nuclear weapons among states that might be considered reasonable candidates for proliferation—specifically, countries that face security threats and have the economic capacity to shoulder a bomb program.[15] Based on our logit models, we simulated the effects of the NPT on such states by using the Clarify program, while setting *US/USSR RIVALRY* and *ENDURING RIVALRY* at 1, *MIDS* at 4, and *GDP PER CAPITA* (LOGGED) at 9 (approximately the GDP per capita of Argentina in 1985). For such states, the estimated annual probability of nuclear weapons pursuit for non-NPT members is 6.65%, whereas the estimated probability for NPT members is 1.14%. Likewise, the

[15]We focus on these factors because they are widely cited determinants of nuclear proliferation.

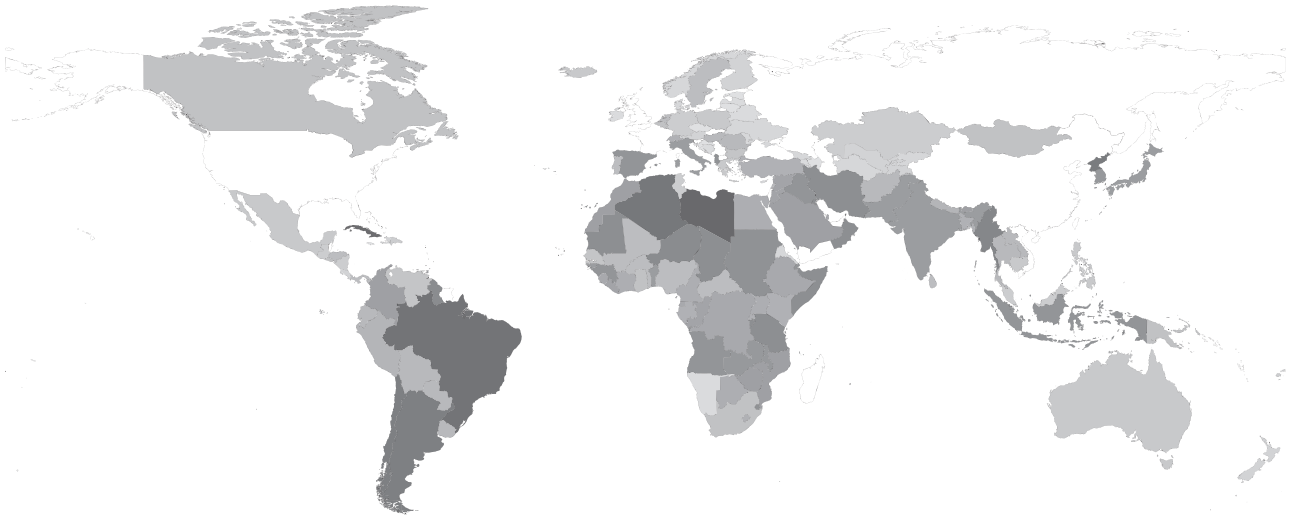

Figure 1. Countries included in matched sample – pursuit

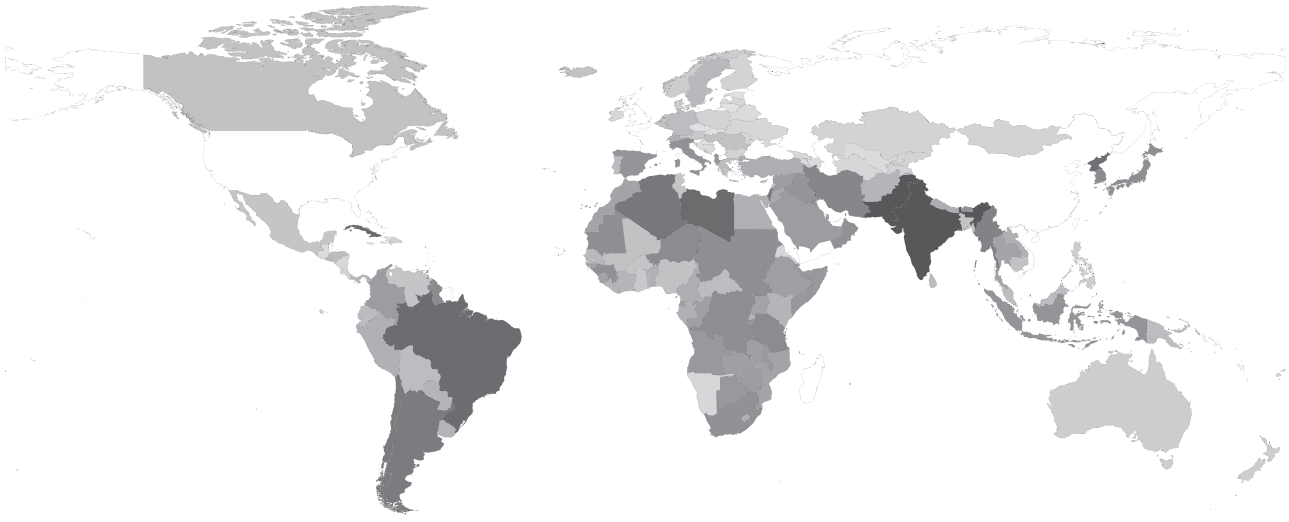

Figure 2. Countries included in matched sample – program

estimated annual probability of having a nuclear weapons program for non-NPT members is 15.00%, compared to 1.42% for members. Both of these differences are not only statistically significant but also substantively meaningful given the potentially dramatic effects of nuclear weapons programs on international security.

Our findings do not imply, however, that the NPT *always* restrains nuclear proliferation. There may still be some truth to the argument made by NPT pessimists. It is indisputable, for example, that some countries—for example, Iraq—sought nuclear bombs despite belonging to the NPT. Yet our "apples-to-apples" comparison of NPT members and non-members indicates that, in general, the NPT is associated with a reduced risk of pursuing nuclear weapons and having a nuclear weapons program. This is the strongest evidence to date of a causal relationship between the NPT and nuclear proliferation.

Our results are generally consistent with what existing studies have shown regarding the other predictors of nuclear proliferation (Singh and Way 2004; Jo and Gartzke 2007; Fuhrmann 2012; Miller 2014). *US/USSR RIVALRY*, *MIDS*, *ENDURING RIVALRY*, *LEADER REBEL EXPERIENCE*, and *PERSONALIST REGIME* are all robustly associated with nuclear proliferation in the positive direction. *NUCLEAR COOPERATION AGREEMENTS* is significant and positive in Model 2, but insignificant at conventional levels of statistical significance in Model 1. The other variables are not significant in either model.

TREATY COMMITMENT PREFERENCES is significant and positive in all our models. Thus, countries that are more likely to ratify the NPT, based on their other treaty commitments, are also more likely to proliferate. Although an in-depth analysis of states' reasons for joining the NPT is outside the scope of this article, this finding suggests that some states may join the NPT in order to bind themselves. In other words, this suggests the NPT is not only screening but may also be constraining.

Sensitivity Analysis

While our matching design has the advantage of providing improved covariate balance and reducing model dependence, it is nonetheless subject to the risk of omitted variable bias. The risk is that our models may exclude a variable that affects both the probability of ratifying the NPT and the probability of nuclear proliferation. We have

Table 4. Logit models of nuclear proliferation

	(1) *PURSUIT*	(2) *PROGRAM*
NPT RATIFICATION	−1.892***	−2.638***
	(0.441)	(0.502)
US/USSR RIVALRY	1.638***	1.524***
	(0.430)	(0.476)
NUCLEAR COOPERATION AGREEMENTS	0.0575	0.0479*
	(0.0413)	(0.0284)
TREATY COMMITMENT PREFERENCES	2.927***	3.010***
	(0.774)	(0.671)
MIDS	0.420***	0.505***
	(0.144)	(0.148)
GDP PER CAPITA (LOGGED)	0.0300	0.205
	(0.229)	(0.208)
SUPERPOWER ALLIANCE	−1.067	−1.137*
	(0.700)	(0.622)
POLITY	−0.00569	0.0103
	(0.0332)	(0.0291)
COLD WAR	−2.782***	−2.303***
	(0.705)	(0.694)
ENDURING RIVALRY	1.223***	1.830***
	(0.355)	(0.361)
LEADER REBEL EXPERIENCE	2.007***	1.913***
	(0.435)	(0.419)
PERSONALIST REGIME	0.194	−0.117
	(0.409)	(0.474)
YEAR	0.136***	0.150***
	(0.0306)	(0.0313)
TIME	−0.216	−0.255
	(0.180)	(0.173)
TIME ^{2}	0.0548***	0.0540***
	(0.0148)	(0.0150)
TIME ^{3}	−0.00428*	−0.00411*
	(0.00238)	(0.00234)
CONSTANT	−280.4***	−310.7***
	(60.26)	(61.80)
OBSERVATIONS	1,658	1,768

Notes. Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

argued that including the Lupu (2013b) estimate of *TREATY COMMITMENT PREFERENCES* in the matching model reduces the risk of omitted variable bias. We test the extent to which our inferences are sensitive to any remaining omitted variable bias. In other words, we evaluate how certain we can be that the NPT has causal effects.

An unobserved covariate may have a very small effect, in which case its exclusion from our model would not threaten our inferences. The question, therefore, is how large the effect of the unobserved covariate must be in order for the inferences we draw from our data to be threatened. In other words, how sensitive are our results to omitted variable bias? A methodology created by Rosenbaum (2002) works according to this intuition. This methodology defines a sensitivity parameter Γ, which is the magnitude of an effect of an unobserved covariate. The maximum level of Γ at which our inferences hold provides a bound on how confident we can be that the NPT has a causal effect. A small Γ indicates that the unobserved covariate with a small effect would lead to different inferences, whereas a larger Γ indicates that the effect of the unobserved covariate would have to be large in order to threaten our inferences. That is, this analysis quantifies how sensitive an estimated casual effect is to omitted variable bias.

The Rosenbaum (2002) analysis indicates that Γ would have to be as large as 3.4 for *PURSUIT* and 6.7 for *PROGRAM* in order to threaten our inference that NPT ratification reduces proliferation ($p<.05$). This means that the probability of a country ratifying the NPT would have to be 3.4 times as large because of a different value in the unobserved covariate despite being similar on the matched covariates in order for our inference that the NPT reduces the risk of nuclear weapons pursuit to change. Likewise, the probability of a country ratifying the NPT would have to be 6.7 times as large because of a different value in the unobserved covariate despite being similar on the matched covariates in order for our inference that the NPT reduces the risk of having a nuclear weapons program to change. These levels of insensitivity to omitted variable bias are far greater than are typically found in social scientific studies, in which Γ is typically estimated at between 1 and 2 (Rosenbaum 2002; Keele 2010). The results of the sensitivity analysis therefore lead us to conclude that we can be confident in our conclusion that the NPT reduces the risk of nuclear weapons proliferation because this inference is highly *insensitive* to omitted variable bias.

Robustness Tests

Alternate Dependent Variable Codings. There are disagreements among scholars regarding which countries pursued nuclear weapons and the years that they did so. We therefore test the robustness of our results using alternative codings of the dependent variables provided by Singh and Way (2004) and Jo and Gartzke (2007).[16] Using these data sets, we estimate models similar to those reported above. The results of these models (reported in Table 5) are generally consistent with those of our main specifications. Most importantly, NPT ratification is significant and negative with respect to both *PROGRAM* and *PURSUIT* in both data sets.

Additional Robustness Tests. The supplementary file reports the results of several robustness tests, indicating that our main results are robust to many alternative specifications.

Conclusions

International relations scholars have made considerable progress in understanding whether and how international institutions can influence state behavior. The effects of a high-profile arms control agreement, the NPT, have nonetheless remained unclear. This should trouble us, given the potentially significant role of the treaty in contemporary international security. Our article brings us closer to resolving a longstanding debate about the efficacy of the NPT.

Our study shows that NPT ratification significantly reduces the probability that states will seek nuclear weapons, even when accounting for the possibility that countries may be more likely to join the treaty when they have already decided to remain nonnuclear. The magnitude of this effect is large when compared to other important predictors of proliferation. The NPT, then, has helped to curtail nuclear proliferation. This does not imply that the treaty is bulletproof. To be sure, some pessimism about the NPT remains warranted; several countries have pursued nuclear weapons despite ratifying the NPT (see Fuhrmann 2012, chapter 9).

An important next step in research on the NPT is to understand variation in its effectiveness. To do so, future

[16]We use updated codings by Christopher Way.

Table 5. Logit models of nuclear proliferation

	(3) Pursuit S&W	*(4) Pursuit J&G*	*(5) Program S&W*	*(6) Program J&G*
NPT ratification	−2.366***	−0.943**	−2.701***	−1.337***
	(0.512)	(0.391)	(0.597)	(0.414)
US/USSR rivalry	1.409***	0.0174	1.483***	0.102
	(0.450)	(0.448)	(0.499)	(0.466)
Nuclear cooperation agreements	0.0432**	0.0445*	0.0475**	0.0338
	(0.0212)	(0.0238)	(0.0242)	(0.0209)
Treaty commitment preferences	2.097***	2.376***	2.353***	2.727***
	(0.570)	(0.738)	(0.580)	(0.761)
MIDs	0.818***	0.352	0.712***	0.670***
	(0.240)	(0.216)	(0.245)	(0.194)
GDP per capita (logged)	0.238	−0.355	0.304	−0.184
	(0.225)	(0.238)	(0.203)	(0.203)
Superpower alliance	−0.347	0.882*	−0.720	0.907*
	(0.507)	(0.485)	(0.566)	(0.506)
Polity	0.0118	−0.0281	0.0264	−0.0377
	(0.0305)	(0.0348)	(0.0302)	(0.0331)
Cold war	−1.443**	−2.574***	−1.116*	−2.344***
	(0.668)	(0.970)	(0.627)	(0.846)
Enduring rivalry	1.066***	3.835***	1.604***	3.929***
	(0.360)	(0.744)	(0.361)	(0.691)
Leader rebel experience	1.381***	1.452***	1.378***	1.239***
	(0.365)	(0.428)	(0.394)	(0.398)
Personalist regime	−0.208	−0.761*	−0.336	−1.005**
	(0.494)	(0.413)	(0.565)	(0.464)
Year	0.0866***	0.223***	0.0937***	0.233***
	(0.0277)	(0.0437)	(0.0276)	(0.0443)
Time	0.402**	−0.00131	0.506**	0.0676
	(0.187)	(0.203)	(0.236)	(0.175)
Time ^{2}	0.0447	0.0110	0.0373	0.0256
	(0.0278)	(0.0196)	(0.0340)	(0.0207)
Time ^{3}	−0.0142***	−0.00936**	−0.0173***	−0.0102***
	(0.00401)	(0.00389)	(0.00570)	(0.00337)
Constant	−183.3***	−449.8***	−198.2***	−471.6***
	(54.26)	(87.18)	(54.17)	(87.98)
Observations	1,660	1,652	1,768	1,774

Notes. Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

work should consider *how* the treaty restrains proliferation. We highlighted several possible mechanisms: greater transparency resulting from the IAEA safeguards, superpower enforcement, domestic politics, and ideational factors. However, our study cannot adjudicate among these mechanisms. Along these lines, it may prove particularly fruitful to explore how domestic factors contribute to the treaty's efficacy. Research on treaties governing human rights and other areas makes clear the importance of domestic political mechanisms (for example, Milner 1997; Conrad 2011, 2014; Hill forthcoming). As in other domains, domestic actors appear to make violations of the NPT more costly and thus less likely (Fuhrmann and Berejikian 2012), but very little research systematically explores this possibility. We hope that this study will encourage a new wave of research on the causes and effects of NPT commitments.

We close with two more general points. The first pertains to the utility of statistical research methods for understanding the causes of nuclear proliferation. Bell (forthcoming) finds that "The majority of variables identified as significant determinants of proliferation fail to provide robust explanations for existing patterns of proliferation." This conclusion may lead some scholars to question the value of quantitative analysis for the study of nuclear politics. To be sure, large-N analysis, like any method, has some key limitations. At the same time, this article illustrates how statistical studies can potentially advance knowledge about how states can constrain the spread of nuclear weapons. There is still cause for circumspection, as our analysis rests on some key assumptions, but our study offers a significant improvement over prior efforts to analyze the causal effects of the NPT.

Second, our findings carry implications for the study of international institutions. A recent wave of research points to the ways in which international agreements significantly influence peace and conflict. We contribute to this research by providing evidence that treaties can have important effects for addressing complex security problems. Policymakers therefore should not dismiss the usefulness of treaties as a tool for meeting key challenges in the twenty-first century. Treaties like the NPT certainly have important limitations. Yet, according to our research, formalized international agreements can provide partial solutions to enduring strategic problems.

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