Nuclear Strategy and Traumatic Events: how nuclear weapons determine foreign policy behavior after negative external shocks

by

Pedro Maues de Avila Goulart

(Under the Direction of Jeffrey D. Berejikian)

Abstract

In this dissertation I investigate different decisions concerning nuclear weapons. I do this by focusing on what I call traumatic events: high-impact external shocks that affect a state's perception of its position in the international system in a negative direction. I integrate the theoretical models of nuclear proliferation and nuclear conflict with cognitive to investigate how traumatic events impact certain decisions. I dedicate one article to one type of decision. In the first article, I investigate the very decision to pursue nuclear weapons. In the second article, I investigate deterrence failure and the decision to start militarized conflict, contrasting nuclear dyads (where both states have nuclear weapons) with other dyads. Finally, in the third article, I investigate decisions to increase military burdens, also contrasting how those differ between nuclear and non-nuclear weapons states.

Index words: [nuclear weapons, international conflict, foreign policy, international relations, arming, international security]

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Dedication

For the peacemakers and all those who work for a world without nuclear weapons.

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To my family back in Brazil, who provided me with so much support in this journey, in particular my mother Carla. To my advisor, Jeffrey Berejikian, my committee members Amanda Murdie and Danny Hill, and all professors at SPIA who gave me great mentorship in research and teaching. Finally, to all my friends, the ones I left in Brazil, and the ones I made in Athens, for all the companionship throughout this journey.

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Chapter 1

Introduction

Nuclear weapons have fundamentally altered the nature of war and, therefore, of international conflict. Nuclear weapons allow for devastating destruction relatively easily and are impossible to defend against (Powell, 1988; Schelling, 2020). They allow for very effective deterrence against invasion and conquest, although their value for compellence is questionable (Sechser & Fuhrmann, 2017). The knowledge required to acquire those weapons is also highly secretive, making the club of countries with nuclear weapons a very exclusive one. Therefore, we expect states' decisions concerning nuclear weapons to be particularly interesting. Moreover, we can expect that states with those weapons will behave differently in their foreign policy decision-making.

This dissertation will contribute to the empirical study of nuclear strategy, including different decisions concerning nuclear weapons capability. I will do this by focusing on what I call traumatic events: high-impact external shocks that affect a state's perception of its position in the international system in a negative direction. I integrate the theoretical models of nuclear proliferation and nuclear conflict with cognitive (Berejikian, 2002; Kahneman & Tversky, 1979b; Levy, 1992, 1996; McDermott, 2001b) and event-based approaches (Hermann, 1990; Stern, 1997) to investigate how traumatic events impact certain decisions. I dedicate one article to one type of decision. In the first article, I investigate the very decision to pursue nuclear weapons. In the second article, I investigate deterrence failure and the decision to start militarized conflict, contrasting nuclear dyads (where both states have nuclear weapons) with other dyads. Finally, in the third article, I investigate decisions to increase military burdens, also contrasting how those differ between nuclear and non-nuclear weapons states.

1.0.1 Background

The United States was the first country to acquire a nuclear bomb, using it to strike the Japanese cities of Hiroshima and Nagasaki in World War II. Since then, that has been the only case of nuclear weapons use to date, and today only nine countries have them. Nevertheless, the introduction of nuclear weapons altered international relations in a dramatic fashion. Preventing both the spread of those weapons and the outbreak of nuclear war among the states that already had them were very prominent goals of the international community in the postwar period, especially during the Cold War.

What makes nuclear weapons game-changers in international relations? Thomas Schelling provides an answer (Powell, 1988; Schelling, 2020). Nuclear weapons provide enormous destructive capabilities while at the same time being nearly impossible to defend. That means states would have enormous strategic advantages if they were to possess such capabilities against states that do not have them.

Things become complex, however, between two states that not only have nuclear weapons but also have second-strike capabilities, that is, the ability to retaliate a nuclear first strike with another nuclear strike. That introduces a credibility problem: since a country striking first with nuclear weapons will result in itself being struck with a highly devastating nuclear strike, threats of deliberate nuclear use in those scenarios become hard to believe, risking making nuclear weapons virtually irrelevant (Powell, 1988).

The way to solve this credibility problem, which has implications for conflict processes, is what Schelling (2020) termed "threats that leave something to chance," deliberate steps that increase the risk of nuclear confrontation by some form of loss of control. The result is that when both states in a dyad have nuclear second-strike capabilities, violent conflict becomes less of a contest of strength and more of a contest of resolve, changing the classic nature of war. That will allow weaker states to prevail if they are more resolved, here translated as the willingness to run risks of nuclear escalation [].

1.0.2 Key concept: Traumatic Events

Given the discussion above, most of the ways nuclear weapons change the behavior of states and the nature of international processes flow from these two observations about nuclear weapons. From that, one can think of two broad questions: first, what makes states pursue the Bomb; and second, in which ways states change their behavior once in its possession.

In this dissertation, I consider the implications of these two major questions under the lens of what I call traumatic events. Traumatic events are high-impact shocks that states suffer with negative consequences. Such events are highly salient and very easy to discern due to their discrete nature, so it is natural that leaders will take them into high consideration when making foreign policy decisions.

In the first article of this dissertation, I consider the first of the major questions listed above: that of what makes states desire and pursue nuclear weapons in the first place. Here, traumatic events directly impact nuclear decision-making as I investigate whether such events can precipitate the onset of nuclear weapons programs. The remaining two articles consider the implications of the second major question: how states use nuclear weapons and how nuclear weapons change their behavior. In these studies, I investigate how nuclear weapons change how states act after going through traumatic events, namely, in decisions to initiate militarized conflict and increase arming levels.

High salience, high impact events can cause a sudden change in perceptions of a state's position in the world. Their discrete nature allows them to get more attention from actors, including states, as opposed to changes that are gradual and therefore harder to discern on a day to day basis. States can learn from crises (Stern, 1997), and external shocks can determine foreign policy changes (Hermann, 1990).

There are two main ways traumatic events could effect changes in foreign policy behavior. First, traumatic events can generate "feedbacks", making leaders to reevaluate their position in the international system, in line with cybernetic theory (Hermann, 1990). Second, due to their negative nature,

traumatic events can change a state's risk orientation through the phenomenon of loss aversion. According to prospect theory, actors tend to be more risk acceptant when they are facing loss frames. Therefore, traumatic events could both cause foreign policy changes by changing leaders' perceptions about their country's position, or by making leaders more willing to take risks.

1.0.3 Research Purpose and Objectives

I divide the research objectives of this dissertation in two broad areas. First, regarding nuclear politics and nuclear weapons interact with foreign policy behavior. And second, how certain events, such as traumatic events, can determine changes in foreign policy behavior.

First and foremost, the main objective of this dissertation is to provide novel findings about nuclear politics, in different questions around this topic. Under one lens, that of traumatic events, I investigate those diverse topics in nuclear politics, topics that scholars have usually studied separately.

In the first article, I consider why states pursue nuclear weapons in the first place, investigating whether traumatic events can precipitate the onset of nuclear weapons programs. Here, I start from the security benefits nuclear weapons bring and how those drive the demand states have for them.

In the remaining two articles, I tackle questions concerning how nuclear weapons change the behavior of states. The second article considers conflict behavior and whether nuclear dyads are more conflict prone after traumatic events. I motivate this study on Schelling's brinkmanship theory (Powell, 1988, 1993; Schelling, 2020), which posits an enhanced role for risk and resolve in conflict between nuclear weapons states, as opposed to non-nuclear dyads where military strength is a more prominent factor. That distinction is crucial for the understanding of the meaning of the "nuclear revolution", or how nuclear weapons change the nature of interstate conflict.

In the final article, I investigate arming decisions and its relationship with nuclear weapons possession. In particular, I use my traumatic events lens to study implications of the "nuclear substitution hypothesis" (Butt, 2015), which posits that states with nuclear weapons have fewer demands for high arms burdens. This study has a more direct connection with the first article, as both have as a starting point the substantial security benefits that nuclear weapons provide.

As for the second broad research objective, I intend to show how particular kinds of events can anticipate particular changes in foreign policy behavior. This is regardless of the presence or absence of nuclear weapons. Across the three articles, I identify and collect data on different kinds of events that can be considered traumatic events, and include them as independent variables in large-N models. The empirical models I report show how such events can be important to predict some foreign policy behavior changes.

1.0.4 Research Problems

The major question about nuclear weapons that motivates all studies of nuclear politics is the following: what makes nuclear weapons unique? or rather, why do states think nuclear weapons are unique? Although the basic military features of nuclear weapons are well known and uncontroversial, its implications for the calculus of foreign policy surrounding them is still a matter of debate.

The first article considers questions of what makes nuclear weapons desirable. Nuclear weapons are costly and risky (Debs & Monteiro, 2017b). What makes states to go through hurdles that can include huge investments in research and development and counter-proliferation measures such as sanctions and even preventive war? Thinking about the security benefits of nuclear weapons under Debs and Monteiro (2017b)'s theoretical model, I posit how the incidence of traumatic events provides a possible answer.

The second article considers questions of how nuclear weapons impact conflict stability not only in terms of nuclear confrontation but in terms of conventional conflict, a question scholars are still actively investigating (Powell, 2015; Rauchhaus, 2009). Under debate are propositions such as the "nuclear peace hypothesis" (Gartzke & Jo, 2009; Jervis, 1988, 1989; Mearsheimer, 1984; Rauchhaus, 2009; Waltz, 1981, 1990). Do nuclear weapons provide for more conflict, less conflict, or no discernible difference? Is the effect conditional on other factors? Does it make a difference whether both or just one state in the dyad have the Bomb? Tackling these questions, I consider how traumatic events bring about different effects on conflict stability depending on the presence or not of nuclear weapons in the states involved.

The final article considers questions of what drives states to arm themselves, and how nuclear weapons play into that calculus. Arming is subject to a "guns versus butter" trade off (Fearon, 2018; Kydd, 2000; Larrosa, 2016; Oren, 1998), but states still need to sustain some basic levels of arms as deterrence against foreign threats (Fearon, 2018). Given all this, nuclear weapons could serve as a cost-efficient substitute for increased arming, easing the trade off, as the "nuclear substitution hypothesis" posits (Butt, 2015). What makes states to pursue increasing arms burdens? How possession of nuclear weapons changes this calculus? I tackle these questions considering how traumatic events changes arming behavior over time, and how this effect is conditional on whether a state has nuclear weapons.

1.0.5 Structure

In the first article, I investigate some determinants of decisions to pursue nuclear weapons. I build from Debs and Monteiro (2016)'s theoretical model of nuclear proliferation to build empirical models of nuclear pursuit. I argue that traumatic events can change a state's evaluation of its security position, making nuclear pursuit more likely. I also make the case that those effects are contingent on the level of public debate in the country. I find that traumatic events can precipitate the onset of nuclear weapons programs, and that countries that are more open to free expression are more vulnerable to this effect. Moreover, on an empirical note, I find that it is of high importance to model the fact that most countries are never at serious risk of starting nuclear programs.

In the second article, I investigate the effect of traumatic events on conflict stability and how this effect changes with the possession of nuclear weapons.I argue that traumatic events produce more risk acceptant behavior through loss aversion. Because nuclear weapons make conflict a competition in risk-taking as opposed to a pure contest of military strength (Powell, 2015; Schelling, 2020), the effects of traumatic events on conflict behavior should be different between nuclear and non-nuclear dyads, with states in nuclear dyads becoming more likely to initiate Militarized Interstate Disputes (MIDs) after suffering those events.The models suggest that most traumatic events I identified make MID initiation less likely among

non-nuclear dyads and more likely among nuclear dyads. The models also confirm previous findings that nuclear dyads are, on average, more likely to experience MIDs (Rauchhaus, 2009).

Finally, in the third article, I investigate how states react to traumatic events by possibly increasing military burdens and how this dynamic changes once a state has nuclear weapons. I consider implications of the "nuclear substitution hypothesis" (Butt, 2015). I argue that one possible implication of the nuclear substitution hypothesis lies in arming trends after traumatic events. I develop a theoretical argument based on cognitive approaches to consider how traumatic events affect arming decisions. Combining that with the theory behind the nuclear substitution hypothesis, I develop predictions of how nuclear weapons capabilities impact arming decisions after traumatic events. My empirical models suggest that nuclear possession can carry some substitution effects after situations of traumatic events, as some nuclear states tend to arm less than non-nuclear states in those high stress scenarios. However, that is conditioned on how a state operationalize its nuclear arsenal through its nuclear posture. Following Narang (2014)'s typology of nuclear postures, I find that substitution effects after traumatic events are specific to states with "assured retaliation" doctrines, that is, states with clear second-strike capabilities and no envisioned missions beyond nuclear retaliation (that is, no-first use doctrines). Moreover, I also find that satisfaction with the status quo is a scope condition for these substitution effects, as my models suggest it only applies to states without any significant revisionist claims.

Chapter 2

Traumatic Events and Nuclear Pursuit

2.1 Introduction

What drives decisions to pursue a nuclear weapons program? Here I investigate some determinants of decisions to pursue nuclear weapons. I build from Debs and Monteiro (2016)'s theoretical model of nuclear proliferation and develop event-based theoretical hypotheses. I argue that some external shocks, or traumatic events, can weaken the willingness constraint for the state to pursue the bomb. I also test hypotheses predicting that the effect of these events is conditioned on how open a country is to free expression. I argue that the level of public debate within a country has a significant impact on nuclear decisions. I identify four kinds of "traumatic events": imposition of sanctions with high anticipated impact; dissatisfaction in high-salience interstate crises; loss of territory; and exit from some alliances.

There have already been some significant contributions on demand-side explanations for nuclear proliferation. Those however focus on more or less stable factors and are agent-specific, analyzing features of international regimes, state leaders, or strategic interactions between different stakeholders (potential proliferator, its allies, and adversaries). Instead, this paper offers an event-specific approach, considering how discrete, high-impact events suffered by the state can impact decisions to proliferate

I argue that some traumatic events are relevant by changing a state's evaluation of its security position, making nuclear pursuit more likely. I also make the case that those effects are contingent on the level of public debate in the country. I then present my country-year dataset covering countries from 1950 to 2000. Finally, I generate and test my hypotheses using event history models.

2.2 The Proliferation Puzzle

Scholars have considered different sources of demand for nuclear weapons, be they security factors or otherwise (Epstein, 1977; Gartzke & Kroenig, 2017; Sagan, 1997, 2011; Saunders, 2019), also including domestic factors (Fuhrmann & Horowitz, 2015; Narang, 2017; Saunders, 2019; Way & Weeks, 2014).

More recent studies have gone beyond the demand side and incorporated the supply side (Brown & Kaplow, 2014; Fuhrmann, 2009; Gartzke & Kroenig, 2009; Jo & Gartzke, 2007; Miller, 2017; Singh & Way, 2004). Similar approaches analyzed the relationship between nonproliferation regimes and nuclear pursuit (Fuhrmann & Berejikian, 2012; Fuhrmann & Lupu, 2016) and how the nuclear fuel cycle dynamics affect proliferation (Herzog, 2020). Other studies have proposed political economy approaches (Choi & Hwang, 2015; Colgan & Miller, 2019; Gheorghe, 2019). It is questionable whether they have a practical use for anything other than nuclear deterrence (Sechser & Fuhrmann, 2017), making most proliferation decisions not only costly but risky (Debs & Monteiro, 2017a).

Debs and Monteiro (2014, 2016) integrate both sides into a theoretical model. In Debs and Monteiro (2016)'s model, decisions to proliferate are a function of strategic interactions between three types of actors: the potential proliferator, its adversaries, and its strong allies. Proliferation decisions require breaking two constraints, the "willingness constraint" (a state must see the prospect of a significant increase in its security position by acquisition justifies the costs of a nuclear program) and the "opportunity constraint" (a state must see that it can succeed in acquisition, which can be thwarted by its adversaries waging preventive war).The model predicts a nonmonotonic relationship between a state's security position and its likelihood of proliferation.Proliferation is expected to happen in the middle zone where security benefits are greater than the costs while not being high enough that they impose more costs for its adversaries than going to war.

2.3 Traumatic events and the willingness constraint to proliferation

The willingness constraint to pursue nuclear weapons is broken if and only if the state perceives that the benefits of nuclear acquisition outweigh the costs of a nuclear program, so states in comfortable security positions will have no desire to pursue nuclear weapons. I argue that traumatic events can bring the state closer to that threshold in breaking the willingness constraint by changing a state's evaluation of its security position.

High salience, high impact events can cause a sudden change in perceptions of a state's position in the world. They are discrete occurrences, easily discerned in a short time frame, unlike changes such as economic or military decline. There is already literature on the impact of certain events on people's social and political attitudes. It has been a long time since scholars have considered how events can affect public opinion (Mueller, 1973; Page & Shapiro, 1992; Sorrentino & Vidmar, 1974). For instance, this literature has investigated the "rally around the flag" effect, where moments of national crises lead to increased presidential popularity (Mueller, 1973; Oneal & Bryan, 1995). More recent studies have investigated the effects of Brexit on hate crimes (Devine, 2021), Donald Trump's victory in the 2016 presidential election on support for the European Union (Minkus et al., 2019)), and terrorist attacks on attitudes towards immigrants (Legewie, 2013).

How could that apply to states? First, Stern (1997), considering whether governments can "learn", argues that moments of crisis can have a significant impact on the policy agenda by crowding out the

attention of leaders, the media, and the informed public, therefore maneuvering the public debate. Going specifically into foreign policy, Hermann (1990) theorized how "external shocks" are one of the determinants of significant changes in a country's foreign policy. He defines "external shocks" as "large events in terms of visibility and immediate impact on the recipient" that serve as "feedbacks" that can provoke policy reorientation (Hermann, 1990). W. R. Thompson (2014) posits a similar role for those external shocks, arguing they can "galvanize policymakers into searching harder for alternative strategies" (Hermann, 1990).

A good example of the nexus between external shocks and nuclear pursuit is the case of France. The turning point for France in its decision to pursue nuclear weapons was the outcome of the Suez crisis, when the United States and the Soviet Union effectively pressured France, along with the United Kingdom and Israel, to withdraw from their invasion of Egypt (Kohl, 2015). After the conflict, France did not find itself in a particularly weak security position that would endanger its survival. However, the intervention by the two Cold War superpowers consolidated the loss of power and France's prestige on the global stage. That built upon France's perception of decline within NATO, with Germany's rearmament and the Anglo-American "special relationship." Moreover, France perceived that depending too much on American defense would require an eventual surrender in Algeria.This created the scenario that led to Frence's nuclear weapons program.

Traumatic events can weaken the willingness constraint to pursue nuclear weapons, either by generating an objective assessment or misperception. The nature of discrete events means leaders and the media evaluate them quickly, even running the risk of overestimating their concrete impact. That is, traumatic events can either provide a clear signal of the decline in security position (in which the event makes a state correctly evaluate the situation), or they could make the state overestimate the event's negative impact due to cognitive biases. In particular, "availability bias" is a heuristic by which actors overvalue easy to recall events, that is, are more "available" (Folkes, 1988; Schwarz et al., 1991; Tversky & Kahneman, 1973), making them overestimate their frequency. The incidence of these events is expected to provoke a perception of a degrading security position, since it seems implausible that states would undervalue the negative impact of these events.

From this, I can generate the following hypothesis:

Hypothesis 1: *States are more likely to pursue nuclear weapons after suffering traumatic events;*

Moreover, those events can produce a change in risk orientation towards more risk acceptance, with loss aversion as a causal mechanism. Discovered in experimental studies and formalized by Prospect Theory (Kahneman & Tversky, 1979b), loss aversion is a mechanism by which most actors take more risks when facing loss frames, or a scenario that is worse than some reference point assumed by the actor. Scholars have already applied those findings to International Relations research (Berejikian, 2002; Jervis, 1992; Levy, 1992, 1996, 2003; McDermott, 2001a, 2004; Vis, 2011). States perceiving a decline in their security position will, on average, be more willing to take risks (such as starting a nuclear program) regardless of the absolute value of their position.

However, framing has a subjective component, making it hard to measure. For that reason, it is subject to "counterframing", when different offers of framings compete with each other, making the settling of

a loss or gains frame by the actor harder to predict. Berejikian (2018) applies this to states and argues that domestic factors can influence counterframing dynamics, since more open and democratic countries would have a larger offer of frames (through public opinion or media.). Although no particular kind of framing is favored to win, a wider offer of different framings destabilizes the settling of either a gain, loss, or neutral frame.

The literature on the impact of external shocks also identified this dynamic. Stern (1997) argues how the public debate over crises influences the process of government learning. Page and Shapiro (1992) note how events require interpretation before they have an impact on public opinion. The media, of course, plays an important role here since most people do not experience those events directly (Boomgaarden & de Vreese, 2007). For the purposes of this study, decisions on nuclear programs are high-level policy decisions, made by political elites. Nevertheless, societies more open to public debate can still influence elite decision-making, mainly in two ways: first, by giving dissenting elites or minority voices inside those elites more channels on which to pressure decision-makers; and second, more indirectly, since more open societies tend to have more democratic accountability, mass public opinion can have some impact on policy decisions.

In summary, countries where public debate is more open allow for a larger variety of viewpoints to potentially influence policymaking and therefore condition the effect of those traumatic events into the final decision. From that, I can generate the following hypothesis:

Hypothesis 2: *The effect of traumatic events on nuclear pursuit is conditioned on how open a country is to public debate and expression;*

The question remains on the direction of this difference. Would countries with higher freedom of expression be more or less vulnerable to this effect of traumatic events on nuclear pursuit? Per the discussion above, the underlying theory that motivates this hypothesis predicts a difference but not specifically a direction. However, we can consider how it could be one direction or the other.

Leaders might be more cautious about pursuing nuclear weapons, and more open public debate would give more leverage to hawkish sectors of the population that do not share the leader's hesitancy. That seems to be the case of India's nuclearization (Narang, 2022). That would make more open countries more vulnerable to traumatic events. On the other hand, more open countries might constrain leaders willing to control the narrative and exploit traumatic events to further nuclear ends. That would make open countries less vulnerable to nuclear pursuit after traumatic events.

2.4 Identifying Traumatic Events

Traumatic events need to have both high salience and high perceived impact. They need to be salient enough to be noted by relevant actors outside the immediate circle of the leader and should create at least the perception that they will have a substantive negative effect on a country's security position in the world stage. I identify four kinds of such events: heavy sanctions, dissatisfaction in high salience crises, territory loss, and exit from some alliances.

Heavy sanctions The first kind of traumatic event is the imposition of heavy sanctions against the state. Taking data from the Threats and Impositions of Sanctions (TIES) dataset (Morgan et al., 2014), I coded as traumatic events any case of sanctions that: a) were actually imposed; and b) were coded as having "major" or "severe" anticipated economic damage. There could be an endogeneity issue here, since some sanctions are imposed exactly to deny states access to strategic materials. However, going over the cases coded by TIES as those of "strategic sanctions," there are five cases that actually fit my criteria (were actually imposed and have high anticipated cost), and all of them happened *after* the states started a nuclear weapons program (Pakistan, India, North Korea, and two cases with Iraq) and therefore had already left the sample.

Dissatisfaction in interstate crises The second kind of traumatic event is dissatisfaction in high-salience interstate crises. Taking data from the International Crisis Behavior (ICB) dataset (Brecher & Wilkenfeld, 2000a; Brecher et al., 2021), I recorded any crises that: a) were coded as leaving the state dissatisfied, regardless of the level of satisfaction of other states (OUTEVL variable, levels 3 and 4); and b) the gravity of the threat was coded as either "political," "territorial," "threat to influence in international system or regional subsystem," "grave damage," and "threat to existence" (GRAVITY variable, levels 2 to 6);

Loss of territory The third kind of traumatic event is loss of territory, collected from the Correlates of War territorial changes dataset (Tir et al., 1998). I coded any loss of territory by a state as a traumatic event.

Relevant exit of security alliances The fourth and final kind of traumatic event is the relevant exit from alliances, taken from the Alliance Treaty Obligations and Provisions (ATOP) dataset (Leeds et al., 2002b). Case by case coding was necessary to capture which specific cases of alliance exit constituted a traumatic event. I considered the following criteria:

- The alliance did not end as a result of its goal being fulfilled (for instance, wartime alliances);
- Alliance was not promptly replaced by another alliance;
- Exit was not a result of an endogenous change in foreign policy orientation by the state in question (due to regime change, realignment, etc.);
- If exit is due to an allied state ceasing to exist as an independent polity, the alliance was not replaced by a new one with the state that incorporated the former ally (for instance, alliances with East Germany after the reunification of Germany);

As for the third condition, I consider "foreign policy orientation" strictly in terms of international alignments and how the alliance serves the state concerning its position in the international system. For example, in 1976 the United Kingdom left an alliance with South Africa, precisely due to South Africa's

apartheid regime. Although the United Kingdom made the decision on its own accord, presumably thinking the alliance's costs were outweighing the benefits, its stance towards apartheid was not strictly related to its position in the international system, so the loss of an ally here still counts as a traumatic event.

2.5 Empirical Analysis

Descriptive Statistics The vast majority of country-years, 91.3% (of 5639 total observations), does not experience any traumatic events. Four hundred forty-five country-years experienced one traumatic event, 39 experienced two, 4 experienced three, and no case experienced four. Of all those events, 297, the majority, corresponded to a year of imposition of a sanction with high-anticipated impact. There were 112 cases of alliance exits I coded as relevant, 100 cases of dissatisfaction in a high-salience interstate crisis, and 63 cases of territory loss.

Figure 2.1 shows the incidence of traumatic events per country over each year. Since there are only four levels of traumatic events and many observations per year, I use a jitter plot to avoid visually overlapping cases. We can see how relatively rare those events are, especially the occurrence of more than one of those events for the same country in the same year. Across all countries, all years in the series saw at least one traumatic event per country, and you can see a larger concentration of cases right after 1990, illustrating the immediate post-Cold War period. Two traumatic events per country-year were rare occurrences, with a lot of them concentrated over the 1960s.

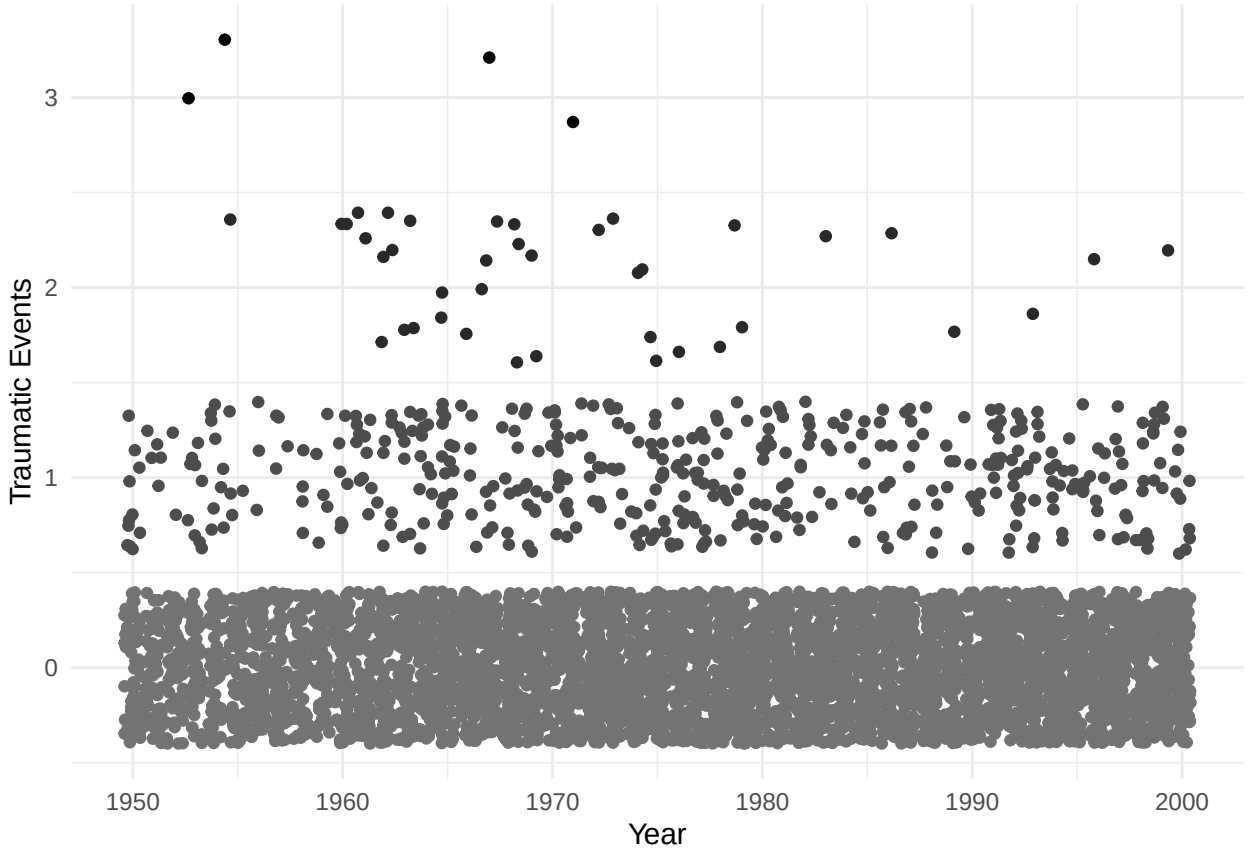

Figure 2.1: Traumatic Events per Country over Time

Cases Among the 19 countries that eventually started nuclear weapons programs in my sample (482 country-years), the proportion of country-years with no incidence of traumatic events falls to 85.8% (414 observations), with 54 cases of one event and 10 of two. All three cases of three traumatic events happened with countries that eventually pursued nuclear weapons.

Table 2.1 summarizes all the cases of nuclear pursuit contained in the sample. The columns show the number of traumatic events each state suffered at 0,1....10 years before they started a nuclear weapons program, with the last two columns providing a sum of these events for the past ten and five years.

Out of 19 cases of nuclear pursuit, nine never experienced any of the coded traumatic events in the ten years prior to the onset of pursuit (Brazil, Romania, South Africa, Iran, Taiwan, North Korea, South Korea, Argentina, and Libya). For all the other ten, there was at least one traumatic event in the previous five years. Two states, Egypt and Pakistan, had suffered more than 10 traumatic events in the previous ten years, with the vast majority happening in the previous five years.

Table 2.1: Traumatic Events before Nuclear Pursuit

Country	Year	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	Total-5 Years	Total- 10 Years
Brazil	1978	0	0	0	0	0	0	0	0	0	0	0	0	0
France	1954	3	3	0	0	1	0	0	0	1	0	NA	7	8
Yugoslavia	1953	0	0	0	1	0	0	0	0	1	NA	NA	1	2
Romania	1981	0	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	1974	0	0	0	0	0	0	0	0	0	0	0	0	0
Iran	1974	0	0	0	0	0	0	0	0	0	0	0	0	0
Iraq	1982	1	1	1	1	1	0	0	1	0	0	0	5	6
Egypt	1968	2	3	1	1	1	2	2	2	0	0	0	11	15
Syria	1997	1	1	0	0	0	0	0	0	0	0	1	3	4
Israel	1958	0	0	0	0	0	0	0	1	0	2	1	1	5
China	1955	0	1	0	0	0	0	1	1	1	1	0	1	5
Taiwan	1967	0	0	0	0	0	0	0	0	0	0	0	0	0
North Korea	1980	0	0	0	0	0	0	0	0	0	0	0	0	0
South Korea	1970	0	0	0	0	0	0	0	0	0	0	0	0	0
India	1964	0	0	0	0	0	1	1	0	0	0	0	1	3
Pakistan	1972	2	3	2	1	2	1	1	1	0	0	0	11	12
India	1968	1	0	0	0	0	0	0	0	0	0	0	1	1
Argentina	1976	0	0	0	0	0	0	0	0	0	0	0	0	0
Libya	1970	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: [a] identification of nuclear weapons programs taken from Jo and Gartzke (2007)

Figure 2.2 provides a bar plot of number of traumatic events in a same year, color-coding whether countries eventually pursued nuclear weapons in the sample. Remind that for survival modeling countries

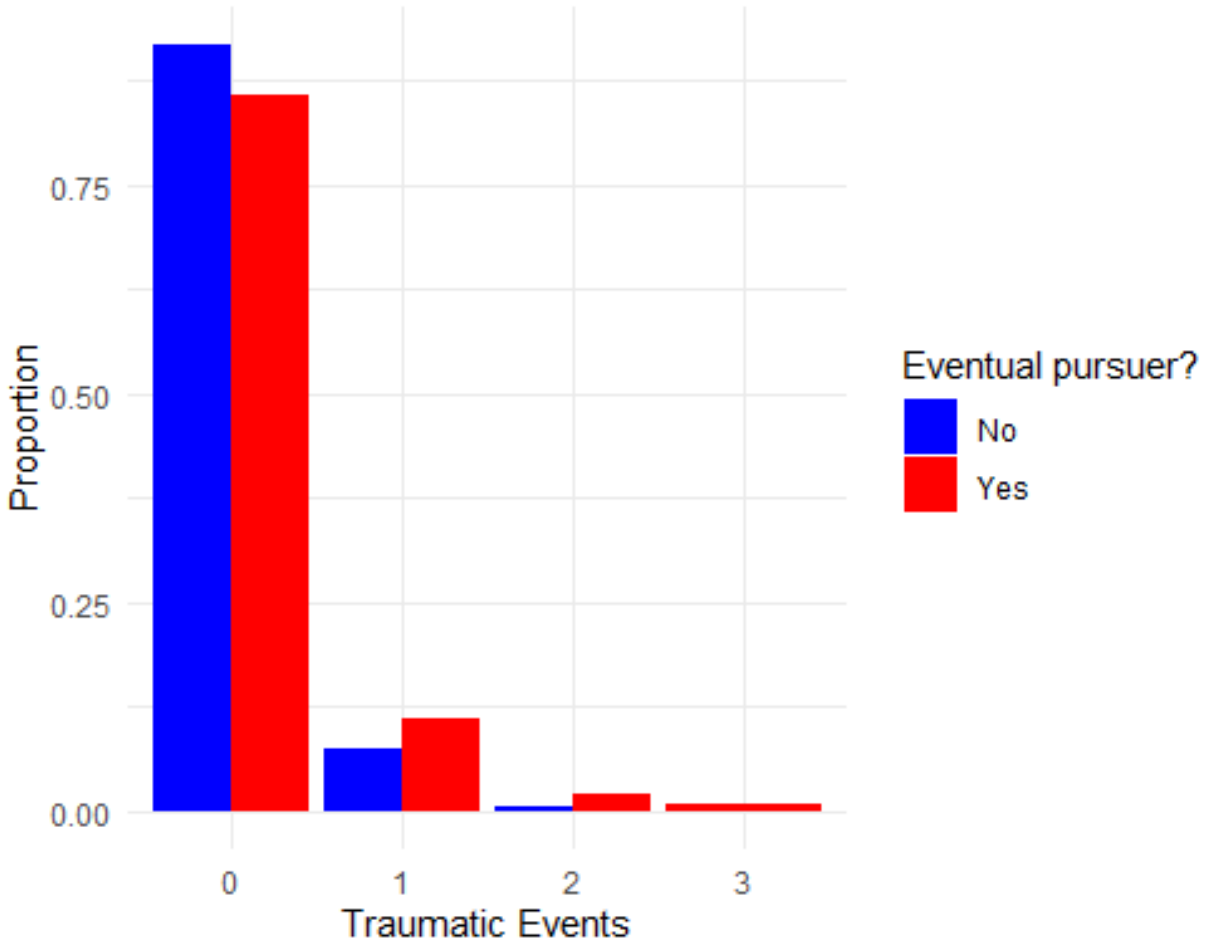

Figure 2.2: Eventual Pursuers and Traumatic Events

leave the sample after they "fail" by starting a nuclear weapons program. Each bar represents each type of state (eventual pursuers or not) at each amount of traumatic events suffered in a single year, but as a proportion of all country-years of the same type. That is, the first bar on the left represents country-years without any traumatic events for non-pursuers as a proportion of the total number of non-pursuer country-years in the sample, and so on. We can see that instances of no traumatic events are the only ones where non-pursuers are more prevalent than pursuers, proportionally.

2.5.1 Empirical Strategy

I tested the hypotheses with a set of survival models, analyzing time-to-event data, the duration over time until a certain event happens (Box-Steffensmeier et al., 2004). Here, the event is the beginning of a nuclear

weapons program. Nineteen events were observed among 5639 observations (country-years) of countries from 1950 to 2000. A state leaves the dataset after it starts a nuclear program, the "failure". The United States, Russia/USSR, United Kingdom, and Sweden are not part of the sample since they already had active nuclear weapons programs when my sample started.

I run models with six different key independent variables: first, two that aggregate all four types of events, a count variable (how many of the four types of events happened at a given year), and a dummy variable (whether or not any of the events happened). Then each of the four types of events separately. For Hypothesis 1, I ran models with no interactive terms. For Hypothesis 2, I interact each key independent variable with an index from Varieties of Democracy (V-DEM) measuring "freedom of expression and alternative sources of information" (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, Altman, Bernhard, Cornell, Fish, et al., 2021b).

I include the following covariates as controls: PAST MIDS is a moving average of militarized interstate disputes the state has been involved in during the past five years (Ghosn & Palmer, 2003; Singh & Way, 2004). This variable is a proxy for a state's security position; NUCLEAR ALLIES is a dummy indicating the existence of a defensive alliance with a nuclear-armed state (Debs & Monteiro, 2017a; Gibler & Sarkees, 2002; Singh & Way, 2004); POLICY SIMILARITY measures the S-score of similarity of alliance portfolios between the state and the current system leader, a proxy for satisfaction with the international status quo (Kang & Gibler, 2013; Signorino & Ritter, 1999); POLITY SCORE indicates regime type; FREEDOM OF INFORMATION, which will be interacted with the key IV for the models testing Hypothesis 2; and NATIONALISM, a variable indicating whether the state at the time had a nationalist orientation as part of its ideology (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, Altman, Bernhard, Cornell, Fish, et al., 2021b; Hymans, 2006); GDP PER CAPITA, the natural logarithm of Gross Domestic Product (GDP) per capita, denoting a state's capability in raw economic terms; and NUCLEAR TECHNICAL CAPABILITIES, a count variable built by Jo and Gartzke (2007) consisting of seven different components of technical expertise necessary for a nuclear weapons program, and how many of them each state has at any given year. NPT ERA is a dummy variable indicating the period after ratifying the Nuclear Non-Proliferation Treaty (NPT), and NPT RATIFICATION is a dummy indicating whether a state ratified the Non-Proliferation Treaty. This last variable excludes the P5 countries since the NPT recognizes them as legally possessing nuclear weapons.

2.5.2 Analysis

For each of the tests I used two different estimators, a Cox proportional hazards model and a split-population model. The Cox model is the most used to estimate the impact of independent variables on the hazard of an event, given its semi-parametric form, which does not require an estimate of the baseline hazard rate (Box-Steffensmeier et al., 2004). The split-population model(Box-Steffensmeier et al., 2004) estimates simultaneous equations, controlling for the fact that some countries are not at a meaningful risk of pursuing nuclear weapons (Bagozzi et al., 2019; Beger et al., 2017; Bolte et al., 2021; Box-Steffensmeier et al., 2005; Svolik, 2008). I include a natural cubic spline in the count version of the key independent variable to check for possible heterogeneous effects at different levels of traumatic events in the same observation.

Finally, in the models presented here that included each of the traumatic events as separate variables, I run separate models with each of those traumatic events. As as robustness check, I also ran models that include all four individual types of traumatic events as covariates together. I show results in the Appendix. These models did not diverge in the underlying picture.

Cox models assume that all units will eventually experience the event.Given the nature of nuclear programs, I also run split-population models, which models some units never experiencing the event by estimating two simultaneous equations: a risk equation estimates whether the unit will experience the event; and for those that will, the duration equation estimates duration until the event. For the risk equation, I included only PAST MIDS and NUCLEAR CAPABILITIES as regressors. I used primarily the Log-logistic distribution, allowing the baseline hazard to both increase and decrease. I later run similar tests with the Weibull distribution for robustness.

Hypothesis 1: traumatic events and nuclear pursuit Figure 2.3 shows coefficient plots for the Cox models testing Hypothesis 1, while Table 2.2 shows the results. In the Cox models, the count variable, sanctions, and loss of territory were all positive and significant at the 0.95 confidence level. In those models, the incidence of traumatic events in the same year was associated with an average increase of the conditional hazard of nuclear pursuit by a factor of 32.27, all else being equal. Imposition of sanctions was associated with an increase by a factor of 5.89 on the average in the hazard of nuclear pursuit, all else being equal. Finally, the loss of territory was associated with an average increase of the hazard of pursuit by a factor of 11.84, all else being equal. Alliance exit, dissatisfaction in crises, and the dummy version of the aggregate of traumatic events did not produce desirable confidence intervals.

Table 2.3 shows results for the split-population models. For interpreting coefficients, those models estimate log-duration until the event, so the meaning of the coefficient's sign is the opposite of that of the Cox models (Box-Steffensmeier et al., 2004). The count variable, territory loss, and now dissatisfaction in crises, were significant at the 0.95 confidence level, while sanctions was significant at the 0.9 confidence level. Here crises had a larger effect, decreasing duration until nuclear pursuit by 97% on average for countries at risk of proliferating, all else being equal. Territory loss decreased duration by 94% for countries at risk of proliferating, and sanctions decreased it by 62.8% per year. Finally, the incidence of any traumatic event was associated with a decrease of 37% in the duration until the start of a nuclear weapons program for countries at risk of doing it.

Considering both the Cox and split-population models for Hypothesis 1, territory loss and imposition of sanctions with high anticipated damage showed strong results. The same was true for the count aggregate variable, indicating the coincidence of such events in the same year might create a substantial effect on the odds of a country deciding to pursue nuclear weapons, even if some events(such as alliance exit) are not relevant by themselves.

The most considerable discrepancy between the Cox and split-population estimators is in the estimates for the crisis variable. Not only does the p-value for this variable drop from 0.9 in the Cox model to reaching statistical significance beyond the 0.99 level, but its impact on nuclear pursuit becomes the largest of all tested key independent variables. That possibly shows the impacts of using the split-population

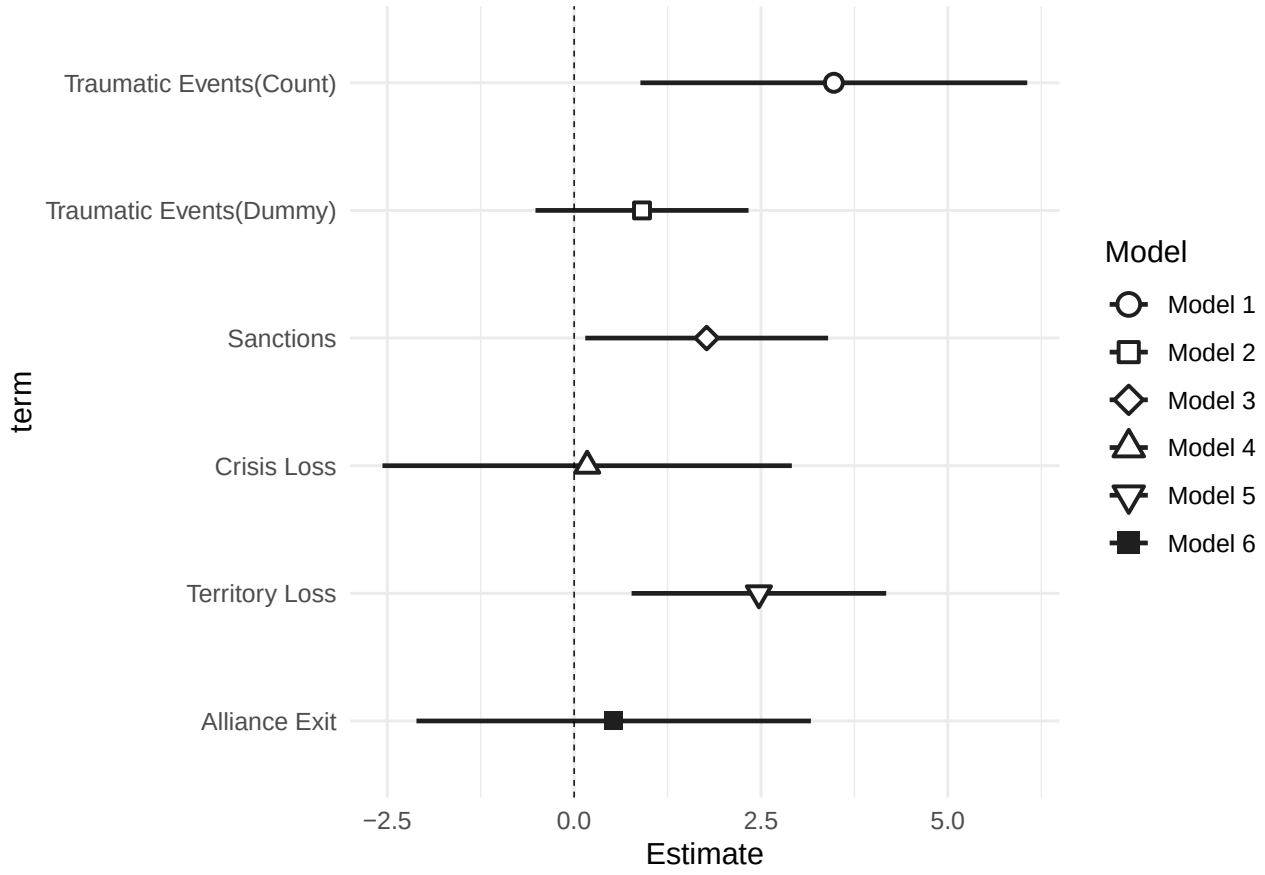

Figure 2.3: Coefficient Estimates for Hypothesis 1 (Cox Models)

Table 2.2: Results for Cox Models- Hypothesis 1

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	Nuclear Weapons Pursuit					
	(1)	(2)	(3)	(4)	(5)	(6)
Traumatic Events(Count)	3.474***					
	(1.320)					
Traumatic Events(Dummy)		0.908				
		(0.727)				
Sanctions			1.773**			
			(0.829)			
Crisis Loss				0.174		
				(1.397)		
Territory Loss					2.472***	
					(0.869)	
Alliance Exit						0.529
						(1.346)
Nuclear Exploration	1.503**	1.243**	1.382**	1.081*	1.297**	1.106*
	(0.640)	(0.615)	(0.628)	(0.592)	(0.611)	(0.597)
Past MIDs	0.299***	0.284***	0.306***	0.279***	0.295***	0.282***
	(0.105)	(0.101)	(0.105)	(0.101)	(0.100)	(0.101)
NPT Ratification(no-P5)	−1.747**	−1.877**	−1.753**	−2.052***	−1.813**	−2.027***
	(0.739)	(0.734)	(0.735)	(0.723)	(0.743)	(0.728)
NPT Era	−1.695	−1.741	−1.737	−1.773	−1.700	−1.770
	(1.161)	(1.178)	(1.172)	(1.187)	(1.162)	(1.187)
Nuclear Technical Capabilities	0.581***	0.604***	0.623***	0.608***	0.588***	0.604***
	(0.199)	(0.194)	(0.206)	(0.191)	(0.190)	(0.191)
GDP per capita(log)	−0.511	−0.586*	−0.577	−0.595*	−0.574*	−0.594*
	(0.350)	(0.352)	(0.357)	(0.354)	(0.333)	(0.355)
Policy Similarity with System Leader	−4.725**	−4.559**	−4.896***	−4.446**	−4.305**	−4.421**
	(1.890)	(1.825)	(1.864)	(1.795)	(1.865)	(1.801)
Nationalism	1.586	1.593	1.860	1.424	1.242	1.414
	(1.147)	(1.143)	(1.178)	(1.142)	(1.132)	(1.145)
Freedom of Information	−4.482**	−4.175**	−4.211**	−3.901**	−4.137**	−3.948**
	(1.976)	(1.920)	(1.941)	(1.840)	(1.945)	(1.852)
Polity	0.161*	0.153*	0.159*	0.143*	0.135*	0.145*
	(0.082)	(0.081)	(0.083)	(0.078)	(0.081)	(0.079)
Nuclear Ally	0.774	0.601	0.609	0.432	0.531	0.453
	(0.655)	(0.647)	(0.639)	(0.648)	(0.640)	(0.650)
Observations	5,639	5,639	5,639	5,639	5,639	5,639
Notes:	***p < .01; **p < .05; *p < .1					

model to control for units that might not be at risk of experiencing the event. Considering the variables I used, what we probably see is that many countries dissatisfied with the outcome of some high-salience crisis either did not have enough technical capabilities to contemplate the nuclear option, or else their security environment was not dangerous enough to make them think pursuing nuclear weapons was a good option. Once we accounted for these factors and split the population to only include states with actual odds of pursuing the bomb, the effect of those crisis episodes proved to be significant for precipitating the decision.

Table 2.3: Split-population Models- Hypothesis 1

	Nuclear Weapons Pursuit					
	(7)	(8)	(9)	(10)	(11)	(12)
Traumatic Events(Count)|Duration	−2.266**					
	(1.117)					
Traumatic Events(Dummy)|Duration		−0.461				
		(0.476)				
Sanctions|Duration			−0.990*			
			(0.581)			
Crisis Loss|Duration				−3.241***		
				(0.544)		
Territory Loss|Duration					−2.702***	
					(0.855)	
Alliance Exit|Duration						−0.284
						(0.748)
Nuclear Exploration|Duration	−0.957*	−0.288	−0.919*	−0.526**	−0.428	−0.750
	(0.559)	(0.391)	(0.500)	(0.206)	(0.337)	(0.478)
Past MIDs|Duration	−0.143**	−0.102*	−0.134**	−0.154***	−0.307***	−0.109*
	(0.071)	(0.061)	(0.060)	(0.057)	(0.093)	(0.056)
NPT Ratification(no-P5)|Duration	0.922**	1.757***	0.969**	0.725***	0.961***	0.876**
	(0.434)	(0.456)	(0.407)	(0.201)	(0.363)	(0.381)
NPT Era|Duration	−0.466	−0.608	−0.367			−0.342
	(0.519)	(0.424)	(0.436)			(0.432)
Nuclear Capabilities|Duration	−0.309**	−0.481***	−0.300**	0.052	0.077	−0.298**
	(0.135)	(0.159)	(0.128)	(0.080)	(0.124)	(0.127)
GDP per capita(log)|Duration	−0.013	−0.182	−0.018	−0.043	−0.180	0.048
	(0.224)	(0.153)	(0.193)	(0.101)	(0.186)	(0.160)
Policy Similarity with System Leader|Duration	2.114**	2.993***	2.096**	1.251**	0.566	1.977**
	(0.931)	(1.002)	(0.854)	(0.506)	(1.002)	(0.832)
Nationalism|Duration	−0.907	−1.174**	−0.895	−0.171	0.007	−0.752
	(0.613)	(0.564)	(0.596)	(0.309)	(0.464)	(0.530)
Freedom of Information|Duration	1.916		1.721			1.715
	(1.189)		(1.105)			(1.071)
Polity|Duration	−0.046	0.035	−0.045	0.023*	0.062**	−0.051
	(0.046)	(0.022)	(0.043)	(0.013)	(0.024)	(0.043)
Nuclear Ally|Duration	−0.197	0.340	−0.219	−0.039	0.403	−0.158
	(0.380)	(0.354)	(0.346)	(0.197)	(0.331)	(0.325)
Past MIDs|Risk	2.811	1.098	2.963	0.036	0.224	2.447
	(2.698)	(0.745)	(3.281)	(0.134)	(0.163)	(2.591)
Nuclear Capabilities|Risk	−0.314	−0.071	−0.296	1.130***	1.725***	−0.430
	(0.842)	(0.422)	(0.766)	(0.384)	(0.604)	(0.934)
Observations	5,639	5,639	5,639	5,639	5,639	5,639
Notes:	***p < .01; **p < .05; *p < .1					

I am interested in checking whether the Split-Population model is providing more information, so I check model fit with ROC curves. ROC curves are a common way to check how well a model with a binary response fits the data (Fawcett, 2006). The curve is built by plotting the model's true positive against false positive rates (given the data) for a grid of threshold values that transform the continuous predictions into binary ones. One can calculate the AUC (Area Under the Curve) metric out of ROC curves, with values around 0.5 indicating non-informative models, while higher values indicate a better model fit to data.

Cox models tend to overfit the data (Ward & Ahlquist, 2018), which means they do not perform well with out-of-sample predictions and are not as useful for forecasting. Because of this, a better way to check how much accuracy the split-population models are adding is to compare them with regular parametric models with the same covariates and the same log-logistic distribution.

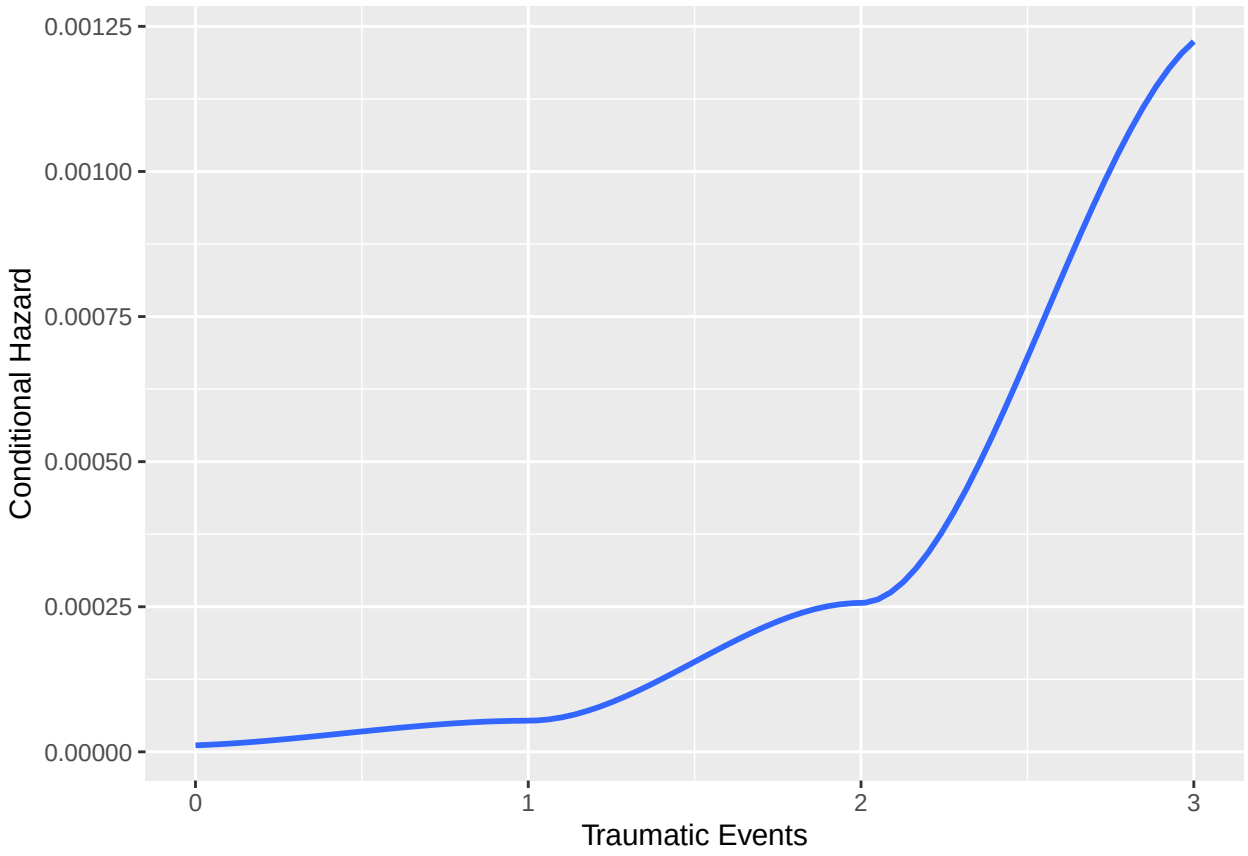

Figure 2.4: Predicted Values, Split-Population Model

Under this metric, there is a clear improvement in model fit for the split-population models compared to the regular models. The AUC metric ranges from 0.91 to 0.95 in the split-population models, and 0.78 to 0.79 in the regular parametric models. ROC curves can be found in the Appendix. Those tests show how important is to model whether countries are at risk of pursuing nuclear weapons.

Figure 2.4 shows predicted values of the conditional hazard of nuclear pursuit for different levels of traumatic events in a year in the split-population models. This can show the behavior of the natural cubic spline on the traumatic events count variable. As the curve shows, the effect on the conditional hazard of nuclear pursuit compounds after each traumatic event in the same year. For each traumatic event happening in the same year, the conditional hazard of nuclear pursuit increases by a factor of 4.7.

Hypothesis 2: traumatic events in open or closed societies Next, I tested models for Hypothesis 2, including an interaction term between my key independent variables and freedom of information. This will check if the effect of traumatic events on the risk of nuclear pursuit should be conditioned on how

open a society is. The Cox models showed promising results for both aggregate variables, the count and dummy ones, and for territory loss independently. The aggregate variables were also statistically significant at the 0.95 confidence level in the split-population models, while territory loss was significant at the 0.9 level. On the other hand, with this estimator, imposition of sanctions was statistically significant at the 0.95 confidence level. In all instances, the coefficient of the interaction was positive, suggesting that the effect of traumatic events on the hazard of nuclear pursuit is larger in more open societies.

For the Cox models, figure 2.5 plots coefficients for the key independent variables, while table 2.4 shows results. The count of traumatic events has the largest effect, with a 0.01 increase in the Freedom of Information index (ranging from 0 to 1) associated with an increase of the positive effect of traumatic events by a factor of 1.11, on average and all else being equal. For territory loss, a 0.01 increase in Freedom of Information is associated with an increase in the positive effect of traumatic events by a factor of 1.08. Finally, with the dummy of traumatic events, a 0.01 increase in Freedom of Information drives a change in the positive effect of hazard of nuclear pursuit by a factor of 1.04. For all models, the coefficient for the independent term for Freedom of Information (the effect of that variable on the hazard of nuclear pursuit in the absence of any of the traumatic events) is negative and significant at the 0.95 confidence level, indicating that on average more open countries have a lower hazard of nuclear pursuit. On the other hand, none of the key independent variables had independent terms reaching statistical significance at confidence levels beyond 0.9.

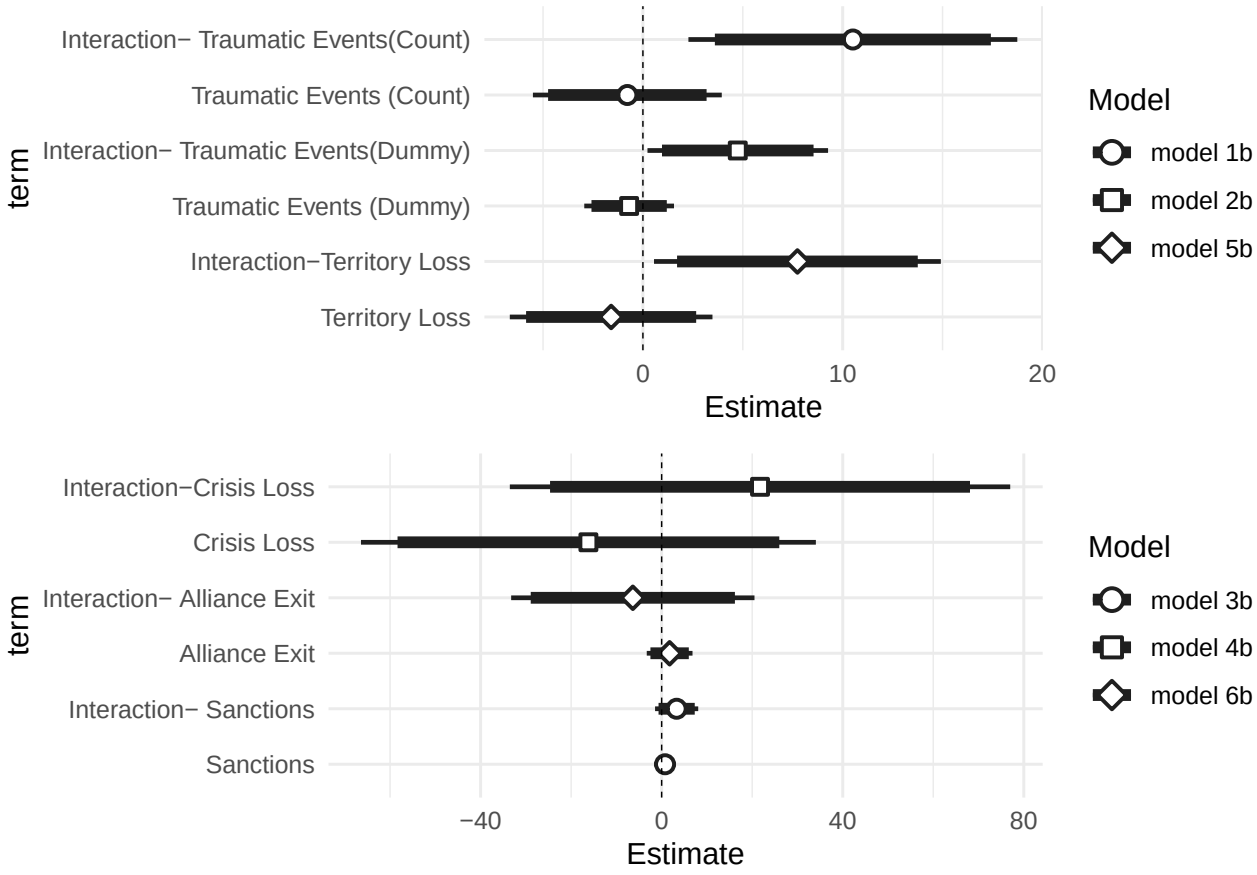

Figure 2.5: Coefficent Estimates for Cox Models- Hypothesis 2

Table 2.4: Results for Cox Models- Hypothesis 2

	Nuclear Weapons Pursuit					
	(1)	(2)	(3)	(4)	(5)	(6)
Traumatic Events (Count):Freedom of Expression	10.510**					
	(4.200)					
Traumatic Events (Count)	−0.780					
	(2.412)					
Traumatic Events (Dummy): Freedom of Information		4.748**				
		(2.306)				
Traumatic Events (Dummy)		−0.690				
		(1.146)				
Sanctions:Freedom of Information			3.306			
			(2.432)			
Sanctions			0.746			
			(1.197)			
Crisis Loss: Freedom of Information				21.728		
				(28.201)		
Crisis Loss				−16.184		
				(25.636)		
Territory Loss:Freedom of Expression					7.735**	
					(3.663)	
Territory Loss					−1.592	
					(2.588)	
Alliance Exit: Freedom of Expression						−6.373
						(13.713)
Alliance Exit						1.754
						(2.579)
Past MIDs		0.313***	0.290***	0.323***	0.309***	0.282***
		(0.100)	(0.105)	(0.106)	(0.098)	(0.101)
Freedom of Expression	−6.032***	−5.428**	−4.899**	−4.240**	−5.534**	−3.863**
	(2.175)	(2.188)	(2.074)	(1.919)	(2.179)	(1.851)
Nuclear Exploration	1.230**	1.136*	1.457**	0.966	0.941	1.088*
	(0.618)	(0.618)	(0.631)	(0.607)	(0.633)	(0.596)
NPT Ratification (no-P5)	−1.936**	−1.989***	−1.849**	−2.053***	−1.908***	−2.050***
	(0.756)	(0.754)	(0.756)	(0.729)	(0.730)	(0.730)
NPT Era	−2.017*	−1.907	−1.857	−1.892	−1.720	−1.713
	(1.167)	(1.183)	(1.176)	(1.194)	(1.179)	(1.191)
Nuclear Technical Capabilities	0.644***	0.561***	0.624***	0.567***	0.573***	0.611***
	(0.183)	(0.187)	(0.204)	(0.193)	(0.187)	(0.191)
GDP per capita (log)	−0.812**	−0.449	−0.545	−0.488	−0.540*	−0.617*
	(0.316)	(0.337)	(0.356)	(0.373)	(0.327)	(0.357)
Policy Similarity with System Leader	−4.384**	−4.522**	−4.835**	−4.481**	−4.431**	−4.374**
	(1.848)	(1.842)	(1.891)	(1.794)	(1.862)	(1.804)
Nationalism	1.054	1.731	1.695	1.689	1.955*	1.470
	(1.130)	(1.190)	(1.220)	(1.165)	(1.172)	(1.154)
Polity	0.173**	0.143*	0.159*	0.133*	0.144*	0.144*
	(0.084)	(0.081)	(0.082)	(0.079)	(0.082)	(0.079)
Nuclear Ally	−0.051	0.549	0.396	0.512	0.628	0.436
	(0.652)	(0.660)	(0.682)	(0.670)	(0.661)	(0.648)
Observations	5,639	5,639	5,639	5,639	5,639	5,639
Notes:	***p < .01; **p < .05; *p < .1					

For the split-population models, the same variables were statistically significant above the 0.9 confidence level. Moreover, imposition of heavy sanctions was significant at the 0.95 confidence level. Table 2.5 shows results for those models. The count variable had the largest effect on nuclear pursuit conditioned to freedom of expression. For each traumatic event in the same year, a 0.01 positive change in the Freedom of Expression and Information index is associated with an average negative effect of 7.1% in the duration until nuclear pursuit for countries estimated to be at risk, all else being equal. Territory loss was associated with an average negative effect in the duration of 6% for each similar change in freedom of information. The corresponding values were 4% for the dummy aggregate of traumatic events and 3.6% for each year of heavy sanctions imposition.

In summary, for Hypothesis 2, the count of all traumatic events, along with territory loss, showed the same strong results as in Hypothesis 1, in both the Cox and split-population models. Sanctions had another promising result, but for this hypothesis that was true only in the split-population model. Finally, the dummy version of any traumatic events showed significance at the 0.95 confidence level in both models, contrary to models testing Hypothesis 1. That is the biggest discrepancy between the Cox and split-population estimators.

Across all models, results suggest that the impact of traumatic events on the risk of nuclear pursuit was larger for countries with higher levels of freedom of expression and information. Territory loss seems to be the most vulnerable to this effect. Moreover, the compounding of different traumatic events has also shown an effect highly conditioned on how open a country is. More open countries are likely to be more susceptible to the impacts of territory loss, or to multiple traumatic events at the same year.

Table 2.5: Split-Population Models- Hypothesis 2

	Nuclear Weapons Pursuit					
	(7b)	(8b)	(9b)	(10b)	(11b)	(12b)
Intercept|Duration	3.385*	7.327***	5.135***	4.252***	4.471**	4.549***
	(1.730)	(2.254)	(1.343)	(1.573)	(2.006)	(1.391)
Traumatic Count*Freedom of Information|Duration	−7.364*					
	(3.817)					
Traumatic Events(Count)|Duration	0.616					
	(1.606)					
Past MIDs|Duration	−0.270**	−0.396***	−0.127**	−0.397	−0.480**	−0.110*
	(0.115)	(0.104)	(0.051)	(0.251)	(0.234)	(0.058)
Nuclear Exploration|Duration	−1.451**	0.014	−0.928*	−0.860	−0.717	−0.751
	(0.661)	(0.465)	(0.512)	(0.692)	(0.602)	(0.482)
NPT Ratification(no-P5)|Duration	0.606	2.117***	0.734**	0.680*	0.699	0.911**
	(0.382)	(0.537)	(0.337)	(0.364)	(0.431)	(0.413)
NPT Era|Duration	−0.558	−0.729*	−0.342	−0.414	−0.482	−0.382
	(0.517)	(0.440)	(0.410)	(0.458)	(0.516)	(0.462)
Nuclear Capabilities|Duration	−0.130	−0.430**	−0.255**	−0.235*	−0.268*	−0.310**
	(0.169)	(0.178)	(0.115)	(0.125)	(0.147)	(0.136)
GDP per capita(log)|Duration	0.120	−0.324	−0.058	0.085	0.080	0.046
	(0.222)	(0.322)	(0.162)	(0.189)	(0.245)	(0.164)
Policy Similarity with System Leader|Duration	1.468	1.533	2.059**	1.197	0.932	2.025**
	(1.031)	(1.051)	(0.801)	(0.947)	(1.146)	(0.877)
Nationalism|Duration	−0.471	−0.933	−0.676	−0.285	−0.241	−0.786
	(0.575)	(0.583)	(0.487)	(0.493)	(0.557)	(0.553)
Freedom of Information|Duration	3.192*	2.978***	1.431	2.153	3.092*	1.696
	(1.659)	(1.015)	(0.973)	(1.467)	(1.647)	(1.094)
Polity|Duration	−0.045		−0.025	−0.040	−0.042	−0.050
	(0.049)		(0.037)	(0.047)	(0.050)	(0.044)
Nuclear Ally|Duration	−0.112	0.941**	−0.084	−0.074	0.108	−0.160
	(0.395)	(0.423)	(0.313)	(0.320)	(0.382)	(0.338)
Log(alpha)	−0.979***	−1.038***	−1.202***	−1.044***	−0.908***	−1.007***
	(0.261)	(0.237)	(0.258)	(0.295)	(0.250)	(0.257)
Intercept|Risk	−2.723	−2.850	1.512	−3.000	−99.953	2.422
	(2.984)	(2.390)	(5.044)	(6.510)	(563.456)	(5.972)
Past MIDs|Risk	−0.108	0.491*	1.717	−1.338	−45.278	2.432
	(0.247)	(0.258)	(1.479)	(1.840)	(209.976)	(2.493)
Traumatic Dummy*Freedom of Information|Duration	1.313*	0.652	−0.220	5.300	115.520	−0.404
	(0.727)	(0.443)	(0.753)	(5.229)	(628.443)	(0.874)
Traumatic Events(Dummy)|Duration		0.508				
		(0.529)				
Sanctions*Freedom of Information|Duration		−3.372**				
		(1.442)				
Sanctions|Duration			0.145			
			(0.440)			
Crisis*Freedom of Information|Duration			−3.040***			
			(0.913)			
Crisis Loss|Duration				54.254		
				(62.985)		
Territory Loss*Freedom of Information|Duration				−77.945		
				(85.275)		
Territory Loss|Duration					1.065	
					(1.841)	
Alliance Exit*Freedom of Information|Duration					−5.024*	
					(2.688)	
Alliance Exit|Duration						−1.048
						(2.375)
Observations	5,639	5,639	5,639	5,639	5,639	5,639
Notes:	***p < .01; **p < .05; *p < .1					

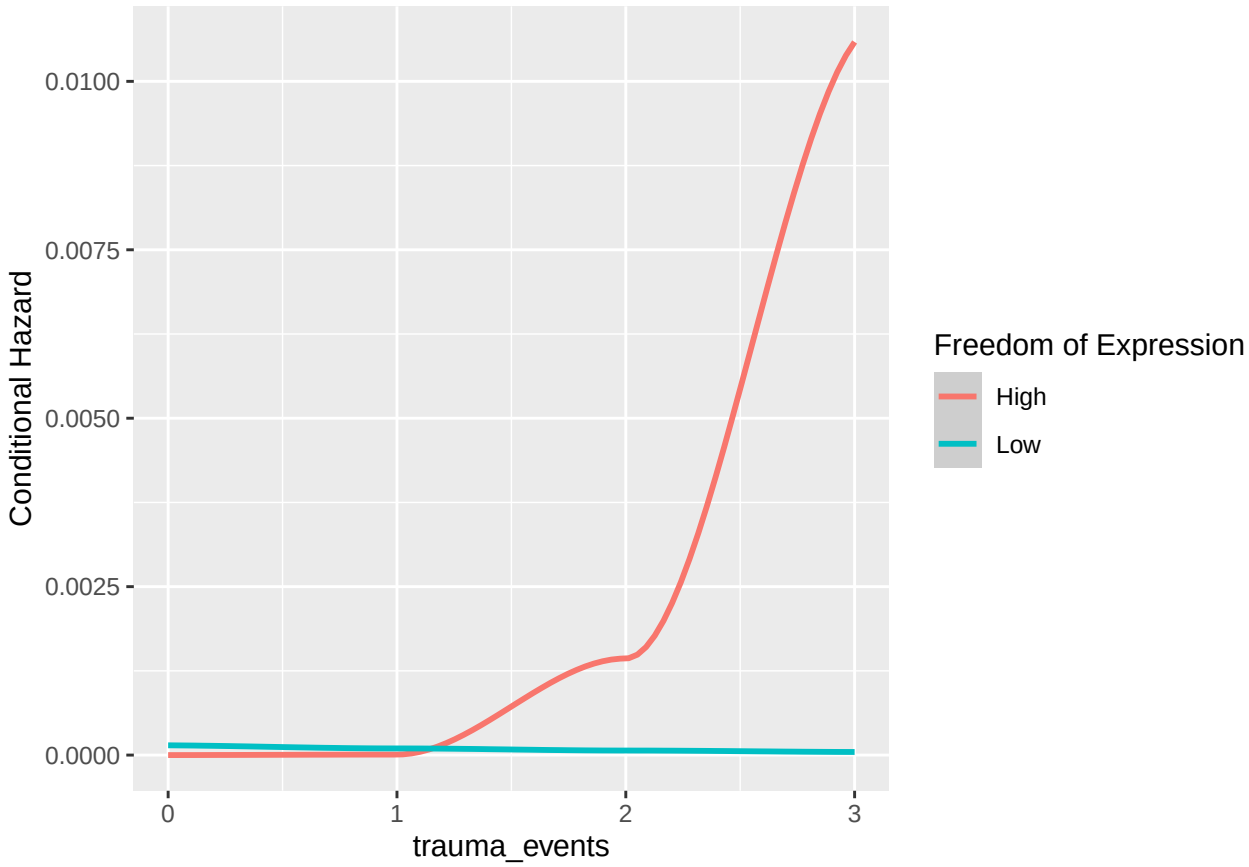

Figure 2.6: Predicted Values for Hypothesis 2, Count IV

Checking for model fit through ROC/AUC, again, we can see that the split-population models improve accuracy over standard log-logistic models. The AUC metric ranges from 0.90 to 0.96 for the split-population models and 0.78 to 0.79 for the regular parametric models (again, see Appendix for plots of ROC curves). So we use those to produce predicted probabilities for the key independent variables that showed statistical significance. For these variables, we can see the positive effect on the conditional hazard of nuclear pursuit is limited to open countries (above the mean), while in close countries (below the mean) it is either negative or close to zero.

2.5.3 Discussion

Models for Hypothesis 1 tested whether traumatic events make nuclear pursuit more likely. Models for Hypothesis 2 tested whether this is conditional on free expression. My models produced evidence for both hypotheses.

Figure 2.7: Predicted Values for H2, Dummy IVs

For Hypothesis 1, count of traumatic events and territory loss both had robust results across the Cox and split-population estimators, increasing the hazard of nuclear pursuit. With lesser confidence, that was also true about imposition of heavy sanctions. That is evidence that some discrete events can weaken the willingness constraint to proliferation (Debs & Monteiro, 2016) and help precipitate decisions to start a nuclear weapons program. Territory loss showed a robust effect, maybe illustrating how salient territory is to a state's evaluation of its security position or aspiration levels (Gibler, 2012). Meanwhile, models with the count of events suggest that, while some events alone are not meaningful in nuclear decisions, compounding multiple such events in the same year can generate that effect.

There was also some evidence that imposition of sanctions with severe anticipated costs helped precipitate nuclear pursuit. However, this evidence seems weaker since the coefficient in the split-population model was significant at the 0.9 confidence level. A caveat here is that imposition of sanctions is the only of the proposed traumatic events that does not happen only in one year (the time unit in the data) but is coded for each year the sanctions are in place.

For Hypothesis 2, both aggregate variables, in their count and dummy forms, had robust results across all estimators. The same was true to a lesser degree to territory loss. Not only the interactive terms with freedom of expression were significant for those, but the coefficients were all in the same direction, with a positive sign. That suggests that the evaluation of traumatic events with respect to the willingness to pursue nuclear weapons is conditional on how open a country is to public debate, with more open countries more vulnerable to negative evaluations of those events, making nuclear pursuit more likely.

These results could be because more closed countries are already, on average, more likely to pursue nuclear weapons in the first place, so external shocks would not make as large a difference as in more open countries. Nevertheless, the results suggest that open countries are indeed vulnerable to evaluating those traumatic events in a manner that makes nuclear pursuit closer in the future. As noted above, it is unclear which type of framing, loss or gains (which determines risk orientations), will be most likely to settle in the presence of counterframing (Berejikian, 2018). Nevertheless, the fact that the key independent variables with the most robust effects in those empirical models were exactly both aggregate versions of all types of traumatic events I identified might be an implication of that instability caused by counterframing. Since nuclear pursuit is rare and open countries have a larger offer of frames interpreting an external shock, all traumatic events likely have unstable methods of evaluation wherever public debate and the flow of information are more open, making nuclear pursuit more likely.

Most results of the Cox and split-population models mirrored each other, providing a robustness check. Since a nuclear weapons program is very costly, many countries are not in the position to even consider starting a nuclear program. Because of this, the split-population model has an empirical advantage over the Cox model, controlling precisely for that fact. For forecasting purposes, model checks through ROC curves showed strong evidence of the added value of split-population models compared with only estimating a duration equation.

The most considerable discrepancies among both estimators were the coefficients for dissatisfaction in high-salience interstate crises, which showed high p-values in the Cox model for Hypothesis 1 but statistical significance at the 0.95 level in the split-population model; and imposition of sanctions with

high anticipated impact, which made the same swing, but for Hypothesis 2. That could potentially show the value of controlling for whether states are at a significant risk of pursuing nuclear weapons at any point in time. For Hypothesis 1, it might be the case that some states who suffered setbacks in major interstate crises had strong willingness constraints (empirically modeled in the risk equation with the moving average of past MIDs) or opportunity constraints(empirically modeled in the risk equation with the level of technical nuclear capabilities), so they still would not start nuclear programs. In contrast, others with more unstable security environments or more nuclear know-how became more likely to decide on pursuing the bomb after a major crisis with a bad outcome.

Meanwhile, for Hypothesis 2, for states either with benign security environments or no significant technical nuclear expertise, the option of pursuing nuclear weapons is likely to be more easily discarded in public debate as unrealistic, unnecessary, or not even considered in the first place, so the instability caused by counterframing is not relevant for this kind of decision. On the other hand, for states with either unsafe security environments or enough technical expertise to make the nuclear option feasible, the conditional effect of freedom of expression and information and the imposition of these sanctions on nuclear pursuit shows up.

Regarding my operationalization of traumatic events, it is encouraging that the count of all four types of traumatic events was the one with the most robust results, with significance at the 0.95 confidence level in all models for Hypotheses 1 and 2. That shows how these events together might have an effect some of them do not have by themselves, and how they compound with each other in the same year to produce more severe evaluations of a country's security environment. Among the four types individually, territory loss was the one with the most robust results across estimators and hypotheses, showing the salience that territory has.

On the other hand, relevant exit of alliances was the only key independent variable that did not show any good results. One reason might be that most of these alliance exits are not as salient as discrete events as the other types of events, so their evaluation by policymakers or the public is not the same. Nevertheless, they still might compound the effects of other, more salient kinds of events. Finally, a possible alternative coding for a future study would be to restrict it only to cases of high-profile alliances, for instance, only including defensive and offensive alliances.

2.6 Conclusion

In this paper, I tested hypotheses about the effects of traumatic events on decisions to start a nuclear weapons program. I argued how some of these events on the international stage could change a state's evaluation of its security position in a way as to weaken the willingness constraint to proliferation (Debs & Monteiro, 2016), making the onset of nuclear pursuit closer in time (Hypothesis 1). I also hypothesized that the effect of these traumatic events on nuclear pursuit is mediated by how open public debate is in the country (Hypothesis 2).

Identifying four types of traumatic events and running event-history models, my results show some evidence that some traumatic events can help precipitate the onset of a nuclear weapons program in the

future. The count aggregate of all four types of events was the most robust key independent variable across models, showing how the compounding of those events can influence the decision to pursue the bomb even if some events in isolation might be irrelevant. Among each type of event, territory loss showed the most robust results, while exit from certain alliances failed to reach desired levels of statistical significance in any of the models. There was also some evidence that the effect of traumatic events on nuclear pursuit is conditional on how open a country is to freedom of expression and information or how open public debate can be. My models find that the effect of traumatic events in precipitating the onset of nuclear pursuit is larger in more open countries. With respect to estimation strategies, the comparison between the Cox and split-population models shows that controlling for how hard it is to be in a position to consider nuclear pursuit is likely to be helpful.

Finally, I present some limitations of this research. As it was clear, the dependent variable here is strictly time until the onset of a nuclear weapons program. It does not consider the duration of nuclear weapons programs, the potential success in acquiring nuclear weapons capabilities, or nuclear forbearance, which are present in Debs and Monteiro (2016)'s theoretical model. Moreover, this analysis focused on states as unitary actors, even if state behavior was determined by cognitive dynamics of leaders and the general public. Personal features of leaders was not modeled here, which could be a good new path for research.

I expect this research to contribute to the empirical investigation of the determinants of nuclear pursuit and nuclear proliferation in general. In particular, I expect to contribute to the application of cognitive approaches to the study of nuclear decision making and the identification of certain discrete events as independent variables capable of predicting the onset of nuclear weapons programs. Further research could work on identifying other relevant traumatic events and go beyond the international stage to consider domestic traumatic events.

Chapter 3

Traumatic Events, Nuclear Weapons, and Conflict Stability

3.1 Introduction

In this paper, I will investigate the effect of traumatic events on conflict stability and how this effect change with the possession of nuclear weapons. The literature has considered how nuclear weapons impact the incidence of conflict. Some have argued that nuclear weapons have a stabilizing effect (Mearsheimer, 1984; Waltz, 1981, 1990), while others argue the opposite (Jervis, 1988, 1989). The Stability-Instability Paradox (SIP) predicts that stability in the nuclear domain leads to instability in the conventional domain (Powell, 2015; Rauchhaus, 2009) and that nuclear weapons will make large-scale conflict less likely while making low-scale conflict more likely. I consider whether differences between nuclear and non-nuclear dyads also play out in how international events affect stability. Adverse external shocks, which I call traumatic events, influence conflict behavior differently for nuclear and non-nuclear dyads.

I argue that traumatic events precipitate re-evaluating the state's security position, generating loss frames. Due to loss aversion, those events will produce more risk-acceptant behavior in states. Because nuclear weapons make conflict a competition in risk-taking as opposed to a pure contest of military strength (Powell, 2015; Schelling, 2020), the effects of traumatic events on conflict behavior should be different between nuclear and non-nuclear dyads, with states in nuclear dyads becoming more likely to initiate Militarized Interstate Disputes (MIDs) after suffering those events. Therefore, my argument combines cognitive approaches, including prospect theory, to account for the effect of traumatic events; brinkmanship theory, which considers nuclear crises competitions in risk-taking; and SIP theory about the relationship between nuclear risk and conventional conflict. The latest two are already combined by Powell (2015) in a game theoretic model that motivates my empirical models here.

I present empirical models of MID initiation in directed-dyad years where I consider the impact of each of those four traumatic events on MID initiation and whether this is different for nuclear and non-nuclear dyads. I identify four types of events that would fit this concept of traumatic events: the imposition of heavy sanctions, dissatisfaction in high-salience crises, loss of territory, and exit from some alliances. The

models suggest that, except for crises, traumatic events make MID initiation less likely among non-nuclear dyads and more likely among nuclear dyads. The models also confirm previous findings that nuclear dyads are, on average, more likely to experience MIDs (Rauchhaus, 2009), one of the predictions of the SIP literature. That means traumatic events can activate SIP by changing the balance of resolve to favor the challenger in the more usual scenarios where resolve favors the defender.

The paper proceeds as follows: first, I summarize the debate on the impact of nuclear weapons on conflict behavior, focusing on brinkmanship theory and the Stability-Instability Paradox. Next, I develop a theory about traumatic events based on prospect theory and a cybernetic approach to foreign policy decision-making, from which I generate my hypotheses. Then I describe my operationalization of traumatic events, identifying four types of such events and the dependent variable. I then describe the other features of my empirical models. I follow with a description of the models' results and a later discussion of their implications for my hypotheses and research questions.

3.2 Nuclear weapons and conflict behavior

A big topic in the study of nuclear politics concerns how nuclear weapons changed the nature and dynamics of interstate conflict. Scholars have debated whether nuclear weapons increase or reduce militarized conflict between states. Optimists argue that nuclear weapons dramatically increase the costs of war, as war would raise the prospect of nuclear use and, therefore, disaster, which in turn would make states more cautious in their bargaining interactions (Mearsheimer, 1984; Waltz, 1981, 1990). Conversely, pessimists argue that misperceptions and cognitive failures will make interstate interactions more dangerous when nuclear weapons are present (Jervis, 1988, 1989). Rauchhaus (2009) tests the nuclear peace hypothesis with quantitative methods and finds that nuclear dyads are less prone to large-scale war but are more prone to lower-level militarized conflict. That is consistent with the Stability-Instability Paradox, a recent theory stating that stability in the strategic (or nuclear) realm will allow for instability in the conventional realm. It seems likely that the effect of nuclear weapons on conflict is rather complex, with different effects according to the distribution of nuclear capabilities, different levels of violence, and different escalation dynamics (Gartzke & Jo, 2009; Powell, 2015; Rauchhaus, 2009).

According to Schelling (2020), what changes in conflict behavior with the arrival of nuclear weapons (on both sides) is the possibility of crises escalating into nuclear brinkmanship scenarios. In Schelling's account, the impossibility of adequately defending against a nuclear strike creates a credibility problem once both states sustain the ability to retaliate in a nuclear exchange. Since a nuclear first strike would result in the initiator being struck with nuclear weapons, a rational actor cannot credibly threaten a deliberate nuclear strike. Schelling's solution to this credibility problem is brinkmanship: states can use nuclear weapons as bargaining tools by taking steps toward the brink, that is, escalating the crisis in a way that increases the risk of a nuclear exchange, what he calls "threats that leave something to chance" (Schelling, 2020).

Consequently, in brinkmanship theory, in crisis scenarios between nuclear weapons states, the balance of military strength stops being relevant in deciding crisis outcomes, as the crisis becomes purely a contest

of resolve (Powell, 2015; Schelling, 2020). As a result, resolve is more salient for determining outcomes of crises among nuclear weapons states than other dyads, so changes in the balance of resolve (or perceptions of it) will have a higher impact on crisis stability among nuclear weapons than among other dyads. On the other hand, for non-nuclear dyads, military power is still the prevalent factor in determining conflict outcomes.

The Stability-Instability Paradox (SIP) was a separate theoretical development, postulating a more explicit and fine-grained relationship between nuclear weapons and conventional military conflict. The theory behind SIP recognizes the axiom that nuclear weapons dramatically increase the costs of war (emphasized by the optimists in the nuclear peace debate). However, it adds that nuclear use is only credible at higher levels of violence and threats suffered by the state threatening it. That means that while nuclear weapons can deter conflict at high levels due to super high costs of war, those effects are not present at lower levels of violence, providing scope conditions for the nuclear peace hypothesis. In the simple version of the theory, nuclear weapons deter high-scale war while allowing for low-scale conflict, as shown empirically by Rauchhaus (2009). A more complex version of the theory considers the variation of nuclear stability, postulating an inverse relationship between nuclear stability (the probability of nuclear exchange) and conventional stability. Here states would be less likely to escalate into larger-scale conflict lest this leads to nuclear confrontation. However, enough strategic stability will allow for more instances of militarized conflict at lower levels of violence, which would generate just enough nuclear risk that states will find acceptable.

Powell (2015) builds a theoretical model that combines the theory behind SIP with Schelling's brinkmanship theory (Schelling, 2020) that explores the interactions between conventional power and nuclear risk. The model centers on a trade-off between power and the risk of nuclear escalation: the more conventional military power a challenger brings to bear in a conflict, the more likely the challenger will win as long as there is no escalation into a nuclear crisis. However, at the same time, the more power the challenger brings to bear, the more risk the defender can generate in response, making it more likely the dispute will escalate into a nuclear crisis, where resolve is the main factor. In this way, military power and resolve to fight interact to determine crisis dynamics within nuclear dyads. If the balance of resolve is known to favor the challenger, the challenger is free to bring more power to bear as it does not fear brinkmanship moves from a less resolved defender. Suppose the balance of resolve is known to favor the defender. In that case, the challenger can still bring some limited power to bear as long it limits the amount of risk the defender can generate to a level, not above the risk the challenger is willing to run. That means an increase in the challenger's resolve increases the likelihood of initiating violent conflict even if the balance of resolve still favors the defender.

Below, I argue that the balance of resolve changes in a potential challenger's favor once that challenger suffers traumatic events. With the perception that the balance of resolve might change in its direction, a nuclear weapon state will be more likely to bring force to bear in a challenge against another nuclear state. As a result, traumatic events should degrade conventional stability among nuclear weapons states, although the same is not necessarily true for other dyads.

3.3 Traumatic Events and Foreign Policy

I argue that high-salience, high-impact events, can cause a sudden and substantial change in a state's assessment of its strategic environment. They are discrete occurrences, easily discerned in a short time, unlike gradual changes such as economic or military decline [1].

Considering the possible sources of major foreign policy change, Hermann (1990) theorized how "external shocks" are one of the determinants of such changes. He defines "external shocks" as "large events in terms of visibility and immediate impact on the recipient." Based on a cybernetic approach, he argues that these shocks serve as "feedback" that can provoke policy reorientation (Hermann, 1990). In a cybernetic system, agents pursue goals while continuously receiving streams of information through stimuli from the environment ("feedback"), based on which they can change course ("steering"). Hermann argues that most foreign stimuli are too weak to be perceived by decision-makers in a salient way, but external shocks have enough impact to serve as stimuli. More recently, W. R. Thompson (2014) posits a similar role for those external shocks, arguing they can "galvanize policymakers into searching harder for alternative strategies" (W. R. Thompson, 2014).

Hermann (1990) considers three types of "major" foreign policy change: "program change" is a change in the means used for the pursuit of foreign policy goals; "problem/goal change" is a change in foreign policy goals; and "international orientation change," a general reorientation of the country's entire foreign policy, which affects multiple types of decisions.

If states perceive such events as harmful, which I call "traumatic events," they can increase the state's resolve by generating loss frames through loss aversion. Discovered in laboratory settings and formalized by Prospect Theory (Kahneman & Tversky, 1979a), loss aversion is a mechanism by which most actors become more willing to take riskier decisions when facing loss frames, that is, when facing a scenario that is worse than some reference point assumed by the actor (usually presumed to be the status quo). A more significant willingness to run risks, by definition, translates into increased resolve, especially within a context of brinkmanship and nuclear crises as characterized by risk-taking competition.

Jervis (1992) argues that loss aversion gives a strategic advantage to status quo defenders in interstate interactions, being, in that sense, a source of stability. However, it makes bargaining harder and, given the subjective component of frames, would make conflict more likely if both states perceive themselves as protecting the status quo. Here Jervis assumes that costly conflict through violence at any level is always risky behavior. Moreover, he argues that even when states are not fully satisfied with the status quo, the risk behind strategies of costly conflict will only make sense to states facing prospects of acute deterioration of their environment when loss aversion becomes an engine of their decision-making.

[1] There is already literature on the impact of certain events on people's social and political attitudes. It has been some time since scholars have considered how events can affect public opinion (Mueller, 1973; Page & Shapiro, 1992; Sorrentino & Vidmar, 1974; Sorrentino et al., 1974). For instance, this literature has investigated the "rally around the flag" effect, where moments of national crises lead to increased presidential popularity (Mueller, 1973; Oneal & Bryan, 1995). More recent studies have investigated the effects of Brexit on hate crimes (Devine, 2021), Donald Trump's victory at the 2016 presidential election on support for the European Union (Minkus et al., 2019), and terrorist attacks on attitudes towards immigrants (Legewie, 2013).

Levy (1992)also argues that loss aversion implies a strong status quo bias, which brings stability in typical situations but instability when a state's position substantially deteriorates. Likewise, while loss aversion generally bolsters deterrence, it can also weaken deterrence depending on the potential initiator's framing of either losses or gains, which is partly formed by subjective judgments. Levy (1996) also notes that perceptions of decline could bring about preemption in conflictual relations.

Berejikian (2002) applies loss frames to deterrence theory, arguing that deterrence is less stable when at least one of the states is in a loss frame. McDermott (2004) argues that loss aversion makes situational and contextual variables very relevant for understanding conflict dynamics and calls attention to the fact that a theory of how framings come about is underdeveloped. Vis (2011) considers the aggregation problem in prospect theory and whether postulates about individual behavior also apply to collective behavior. He argues that a series of empirical studies show that the aggregation problem for prospect theory and loss aversion is not as problematic as one might think. Studies of collective behavior have shown loss aversion patterns similar to individual behavior.

That would mean that states perceiving themselves as in a loss frame will be more resolved to fight to recover from their recent setbacks, independently of their absolute security position. I argue that traumatic events can generate loss frames, making states more willing to take risks and increasing their resolve to fight. A state experiencing a loss frame will create the perception that the balance of resolve is changing in its favor. In nuclear dyads, this increases the maximum brinkmanship risk the challenger is willing to run, therefore increasing how much power it will bring to bear. In scenarios where the challenger was initially not willing to bring any power to bear (that is, not starting any form of militarized dispute), that could mean this new scenario will see an increased likelihood that the challenger will initiate a MID.

One possible case to consider here is the a MID Pakistan initiated against India over Kashmir in 1994, and lasted until 1999. That territorial dispute over Kashmir had been ongoing since 1947, but Pakistan hadn't initiated such a MID since 1985. In 1987, Pakistan acquired nuclear weapons capabilities, in which India followed the next year. In 1990, a huge crisis erupted in India-controlled Kashmir, triggered by sectarian violence in the area followed by Pakistani declarations of concern that caused India to claim political interference. The crisis lasted for five months. At the time, U.S. intelligence assessed that Pakistan was preparing to assemble its nuclear weapons during the crisis, but it never escalated to a military confrontation across the borders. Pakistan, however, left the crisis dissatisfied with the situation in Kashmir (it agreed to close training camps for Kashmiri militants). Three years later, it started the militarized conflict that lasted for the rest of the decade, leading to the Kargil War in 1999 (Brecher & Wilkenfeld, 2000a; Brecher et al., 2021).

In summary, loss aversion can increase a state's resolve when it perceives itself as in a loss frame. Because the balance of resolve impacts conflict dynamics differently for nuclear and non-nuclear dyads, loss frames will have a particular effect on nuclear dyads. Here, suppose a potential challenger enters a loss frame. In that case, it will be more likely to use violence to pursue that challenge since crises among nuclear weapons states are more contests of resolve than military strength, and loss frames will increase a state's resolve. Meanwhile, traumatic events can precipitate loss frames by generating feedback for leaders.

From this discussion I can generate the first hypothesis:

Hypothesis 1: *Nuclear armed challengers are more likely to start militarized conflict with another nuclear armed state after the challenger has recently suffered traumatic events;*

Resolve, of course, is also relevant in crises among non-nuclear dyads. However, here resolve is relevant because it feeds into military strength through a willingness to fight. However, since nuclear brinkmanship is not possible, the balance of resolve is not an independent element determining conflict dynamics, and resolve is, therefore, not as prevalent a factor in non-nuclear crises as opposed to nuclear crises. From this, I can generate the second hypothesis:

Hypothesis 2: *The effect of traumatic events on deterrence failure will differ from non-nuclear to nuclear dyads in a positive direction, either reversing from decreasing to increasing, intensifying increasing effects, or mitigating decreasing effects*

In numerical terms, this all means a positive change in the slope for the effects of traumatic events on MID initiation going from a non-nuclear to a nuclear directed dyad-year. That means that if traumatic events make MID initiation of a given directed dyad-year more likely, changing that dyad from non-nuclear to nuclear will aggravate those effects. If, however, traumatic events make MID initiation less likely in non-nuclear dyads, changing the dyad into a nuclear one will either moderate this effect or change the sign of the relationship, making MID initiation more likely.

3.4 Empirical Strategy

Traumatic Events Given the discussion above, I now more clearly define and operationalize traumatic events. Traumatic events are severe international shocks that negatively affect the state, if not strictly in the material sense, at least in a symbolic sense, producing a substantial distaste in the country's general public and its decision-makers, capable of producing a loss frame. Therefore, I operationalize four kinds of traumatic events:

- Heavy sanctions: sanctions that were imposed and considered to have a high anticipated impact, as coded by the Threats and Impositions of Sanctions (TIES) dataset (Morgan et al., 2014);
- Dissatisfaction in interstate crises: interstate crises where the state was left dissatisfied, and the gravity of the threat was coded as either "political," "territorial," "threat to influence in the international system or regional subsystem," "grave damage," and "threat to existence" by the International Crisis Behavior (ICB) dataset (Brecher & Wilkenfeld, 2000b; Brecher et al., 2021);
- Loss of territory: any loss of territory, as coded by the Correlates of War territorial changes dataset (Tir et al., 1998);
- Exit from some alliances: exit from alliances that could be considered traumatic. I took data from the Alliance Treaty Obligations and Provisions (ATOP) dataset (Leeds et al., 2002a) and coded which were considered traumatic events by hand. I excluded cases where the exit was due to goals being fulfilled, domestic politics considerations, replacement by another alliance, or because the state ceased to exist as an independent polity;

For the models tested here, the key independent variables will be normalized occurrences of each of these types of events for State A (the potential challenger) in the previous five years to the observation, with the directed dyad-year as the unit of analysis. That turns those variables from discrete to continuous values. The reason I did this is to account for the wide range of possible values. It does not seem reasonable to expect that the effect of traumatic events going from one to two be the same as the one going from something like seven to eight, I choose this form of measurement.

Dependent Variable The dependent variable is the initiation of a Militarized Interstate Dispute (MID), as coded by the Correlates of War project (G. Palmer et al., 2022). I code an event of the dependent variable when State A of the dyad is the primary initiator of the MID against State at that given year. I run models alternating each of the four types of events. To compare nuclear and non-nuclear dyads, I interact each key IV with a dummy indicating whether the dyad is a strict nuclear dyad, one where both states have nuclear weapons.

My sample consists of 734261 directed dyad-years, of which only 1038 saw State A initiating a MID against State B as the primary initiator. Of these, 60 were MIDs among nuclear states, where both the initiator and the target possessed nuclear weapons. I use bivariate probit models with partial observability to account for both dyad relevance and rare events. Xiang (2010) details how this method can model dyad relevance by running simultaneous equations with the same outcome variable. Besides the standard equation, the models also run an equation where MID initiation is regressed on minimal distance (Schvitz et al., 2022) and a dummy for whether at least one of the states in the dyad is a superpower. That equation models relevance, that is, whether the observation has a meaningful risk of experiencing MID initiation instead of using a reduced sample defining a priori criteria for what constitutes a relevant dyad.

I also include the following control variables in the standard equation: CINC RATIO, the ratio of both states' CINC scores, a measure of the balance of power (Singer, 1988; Stuckey, 2012); JOINT DEMOCRACY, a dummy indicating whether both states are democracies, as measured by Varieties of Democracy (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, Altman, Bernhard, Cornell, Fish, et al., 2021a); NATIONALISM, a dummy indicating whether nationalism legitimates the regime of State A above average, as measured again by V-DEM; TERRITORIAL THREAT, a continuous indicator of State A's territorial threats measured by Gibler (2012); RIVALRY, a dummy indicating whether the dyad is in a strategic rivalry, as coded by W. Thompson and Dreyer (2011);

3.5 Results

Among nuclear dyads, imposition of sanctions and loss of territory was associated with higher likelihoods of MID initiation, providing evidence for Hypothesis 1. On the other hand, exit from alliances showed a decrease in MID initiation. The models are consistent with previous evidence that nuclear dyads are more likely to go through MIDs than non-nuclear dyads. This condition holds across all levels of all traumatic events identified here.

The models show support for Hypothesis 2 for all types of traumatic events: changing a dyad from non-nuclear to nuclear will change the effect of sanctions from no discernible effect to destabilizing; of dissatisfaction in interstate crises from stabilizing to no discernible effect; of territory loss from stabilizing to destabilizing; and of alliance exit from more destabilizing to less destabilizing (moderating the decreasing effect). No traumatic event had an increasing effect on MID initiation for non-nuclear dyads.

Figure 3.1 shows predicted probabilities for the sanctions model, with 95% confidence intervals. For this first model I include also a histogram to make it clear the traumatic events variables are in a continuous scale. The vertical axis represents predicted probabilities of a positive outcome for both the relevance and conflict equations jointly. The horizontal axis represents the normalized key IV of imposition of sanctions with a high anticipated impact in the past five years, with different regression lines for nuclear and non-nuclear dyads. Among nuclear dyads, the imposition of high-impact sanctions in the previous five years increases the likelihood of MID initiation by an average of 26%(25.5% - 28.9%) from no sanctions to five years o sanctions imposition. Holding covariates at their median values, predicted probabilities of MID initiation for nuclear dyads are 3.97% (3.94% - 4%) when the potential attacker has not suffered any heavy sanctions and 5% (5.02% - 5.08%) for cases of five years of imposition of sanctions.

For non-nuclear dyads holding covariates at their median values, the predicted probabilities of MID initiation for non-nuclear dyads are 3.2% (3.25% - 3.33%) in the absence of past sanctions, and 2.8% (2.82% - 2.87%) at five years of sanctions, an average 13% (12% - 16%) decrease in the probability of MID initiation.

Figure 3.2 shows predicted probabilities for the model with dissatisfaction in high-stakes international crises as the key IV. Holding covariates at their median values, the predicted probabilities of MID initiation among nuclear dyads are 3.98% (3.93% - 4.02%) in the absence of recent crises where the potential attacker was dissatisfied with the outcome, and 4.1% (4.07% - 4.16%) at extreme values, an average 5% (1% - 6%) increase from lowest to highest values.

Among non-nuclear dyads, dissatisfaction in past crises decreases the likelihood of MID initiation by 12% (11% - 15%) from zero to the highest values. Holding covariates at their median values, the predicted probabilities of MID initiation for non-nuclear dyads are 3.31% (3.28% - 3.35%) in the absence of recent dissatisfaction in crises and 2.91% (2.87% - 2.94%) at the highest values.

Figure 3.3 shows predicted probabilities for models with loss of territory as key IV. For nuclear dyads, loss of territory in the preceding five years increases the likelihood of MID initiation by 13% (10% - 15%) from zero to the highest levels. Holding covariates at their median values, the predicted probabilities of MID initiation among nuclear dyads are 3.93% (3.89% - 3.97%) at zero instances of territory loss and 4.45% (4.40% - 4.49%) at the highest values.

For non-nuclear dyads, the recent loss of territory decreases the likelihood of MID initiation at a given year by 10% (9%- 13%) from zero to the highest values. Holding covariates at their median values, the predicted probabilities of MID initiation among non-nuclear dyads are 3.16% (3.13% - 3.2%) at zero instances of territory loss and 2.84% (2.80% - 2.87%) at the highest values.

Figure **??** shows predicted probabilities for models with the relevant exit of alliances as key IV. For nuclear dyads, alliance exit in the preceding five years decreases the likelihood of MID initiation by 8.5% (7% - 8.6%)from zero to the highest levels. Holding covariates at their median values, the predicted probabilities

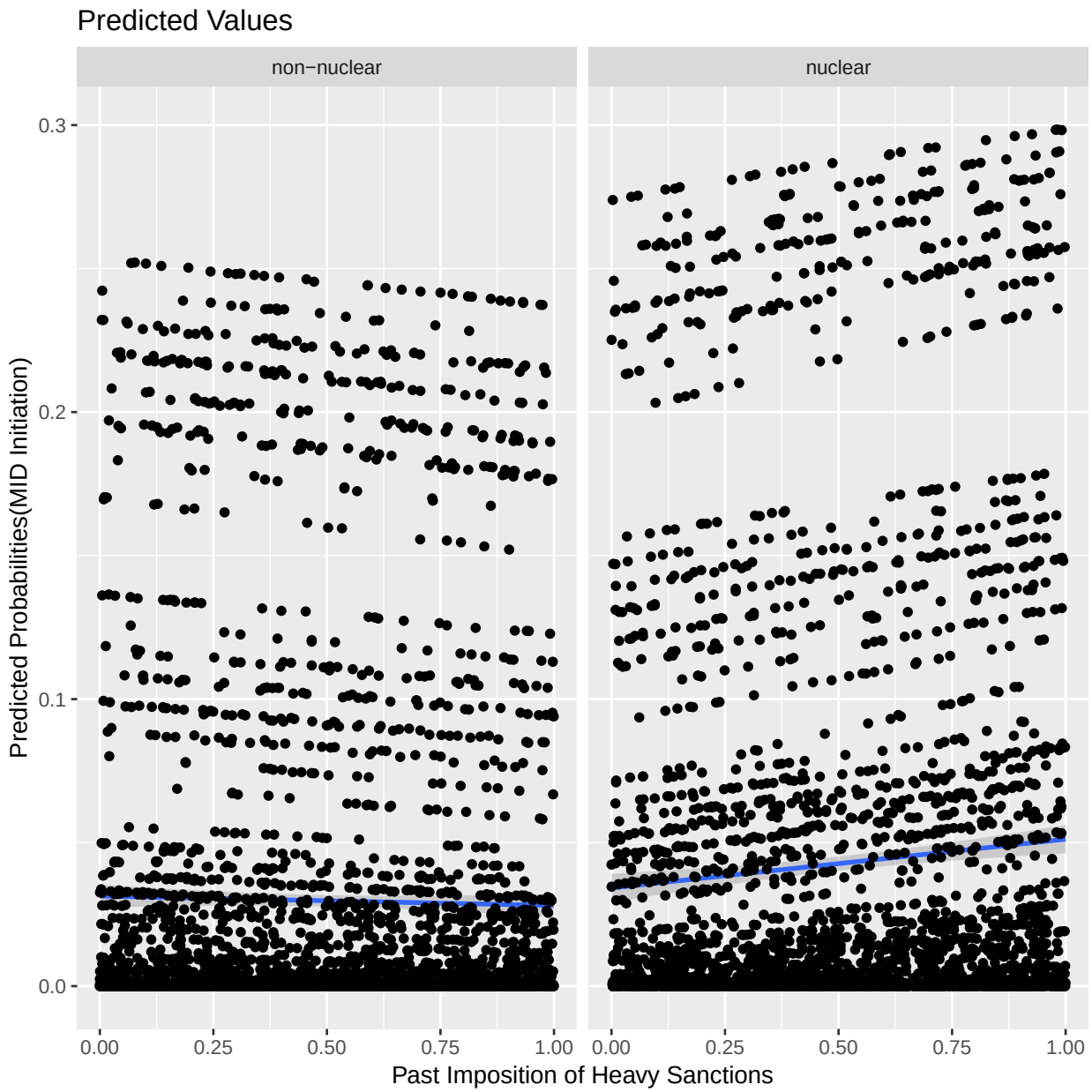

Figure 3.1: Predicted Probabilities- Sanctions

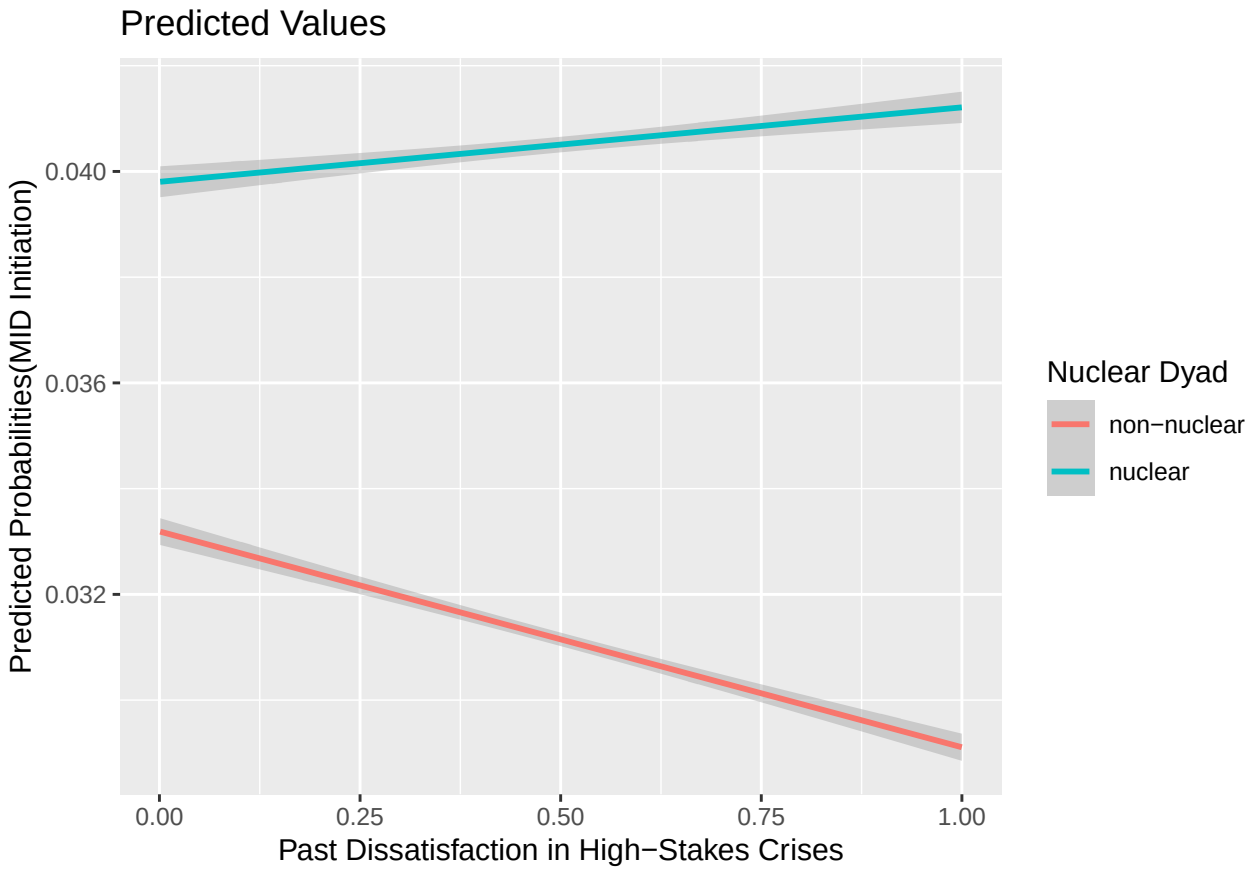

Figure 3.2: Predicted Probabilities- Crises

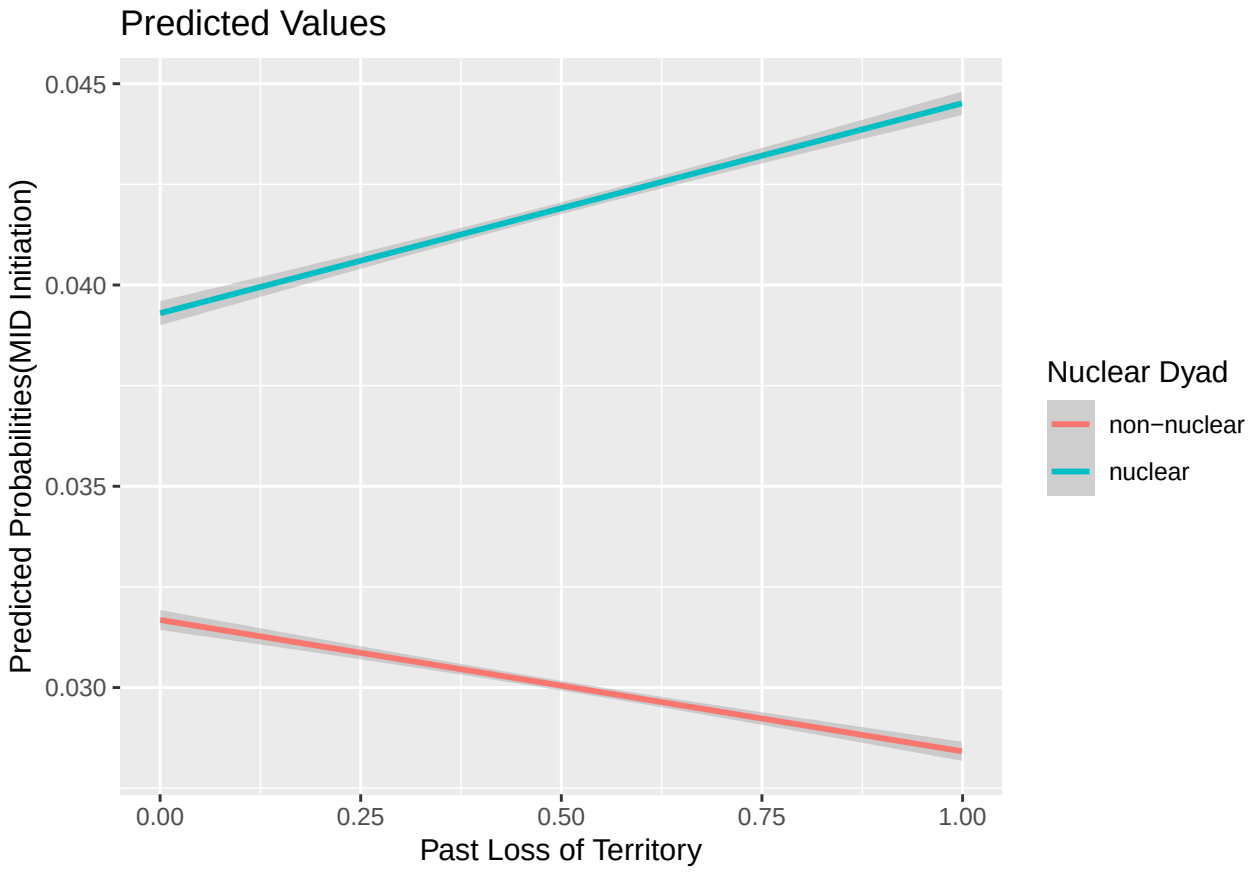

Figure 3.3: Predicted Probabilities- Territory Loss

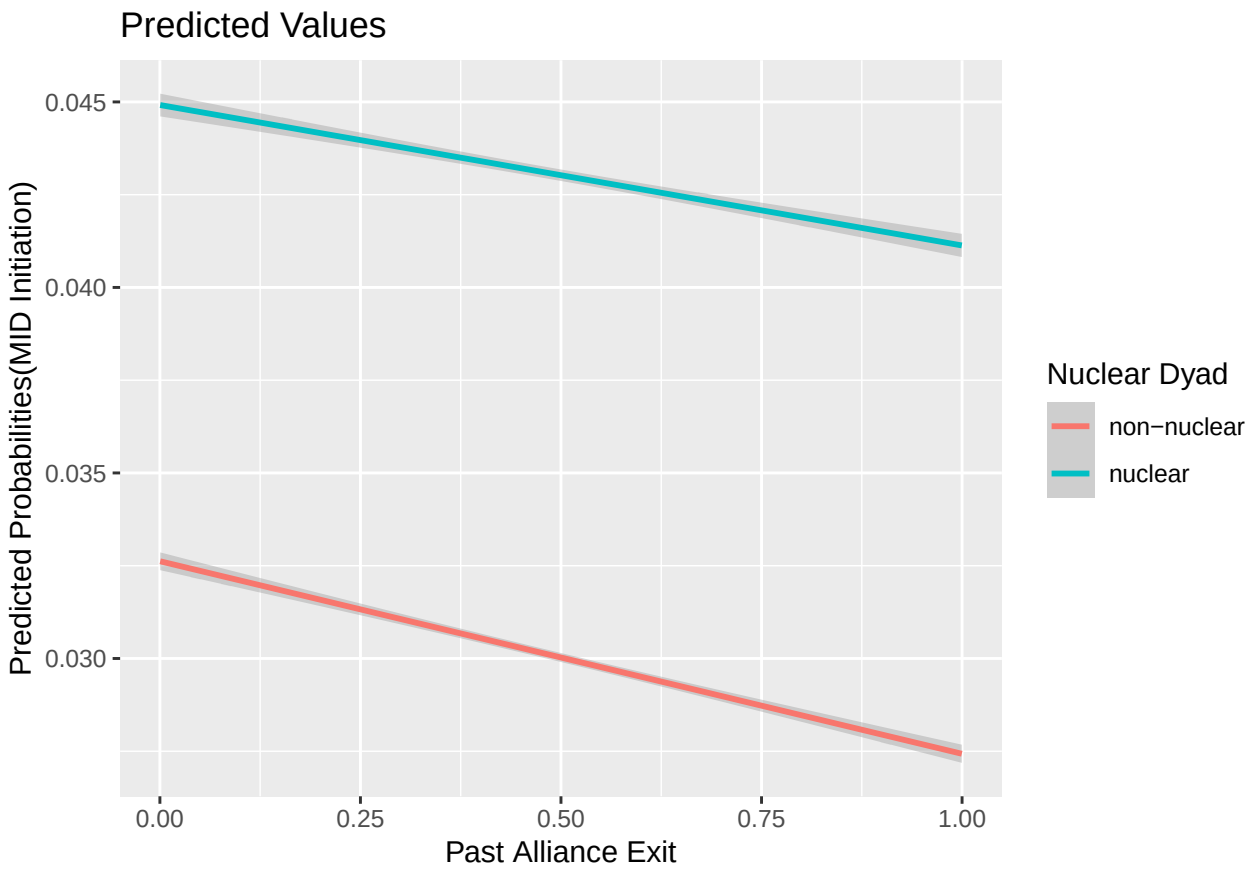

Figure 3.4: Predicted Probabilities- Alliance Exit

of MID initiation among nuclear dyads are 4.49% (4.44% - 4.45%) at zero instances of alliance exit and 4.11% (4.07% - 4.15%) at the highest values.

For non-nuclear dyads, recent exit from some alliances decreases the likelihood of MID initiation at a given year by 16% (14% - 18%) from zero to the highest values. Holding covariates at their median values, the predicted probabilities of MID initiation among non-nuclear dyads are 3.26% (3.22% - 3.29%) at zero instances of alliance exit and 2.74% (2.71% - 2.77%) at the highest values.

3.6 Discussion

The models suggest traumatic events will make a nuclear weapon state more likely to initiate a MID against another nuclear weapons state, even if the likelihood of MID initiation was already much higher for nuclear dyads than non-nuclear dyads. The exception here was the exit from alliances. The models, therefore, produce some evidence for Hypothesis 1.

The models also suggest that nuclear dyads exhibit different conflict behavior than non-nuclear dyads, providing evidence for Hypothesis 2. Changing the nature of the dyad from non-nuclear to nuclear will change the effects of sanctions, dissatisfaction in crises, and territory loss, on MID initiation, from decreasing to increasing. Alliance exit decreases the probability of MID initiation for both dyads, but the decrease is more moderate for nuclear dyads than for non-nuclear dyads. For all four types of traumatic events, nuclear status influences effects on MID initiation in the same direction, either changing the sign of the relationship from negative to positive or moderating a decreasing effect.

The theoretical argument that motivated the empirical models in this study states that the difference in conflict interactions between nuclear and non-nuclear dyads is that, for non-nuclear dyads, violent conflict is primarily a contest of strength, while for nuclear dyads is primarily a contest of resolve. Traumatic events would increase the potential challenger's resolve by generating loss frames. While to identify my empirical models I treated each of the four types of traumatic events as producing equivalent effects, the models indicate some relevant differences. Although, as a possible loss frame mechanism, they would be theoretically similar, they could also produce different additional effects that would impact the state's ability or willingness to wage militarized conflict.

What they all have in common that is of interest for this study is the comparison with non-nuclear dyads. All types of traumatic events impact conflict behavior differently between nuclear and non-nuclear dyads, all in the same direction. For sanctions, crises, and loss of territory, changing a dyad from non-nuclear to nuclear changes the sign of the effects of those events on MID initiation from negative to positive. These events make MID initiation less likely in non-nuclear dyads and more likely in nuclear dyads. Meanwhile, alliance exit makes MID initiation less likely for both types of dyads. However, the decreasing effect is more moderate in nuclear dyads. Hence, the disparity in the probability of MID initiation between nuclear and non-nuclear dyads increases at higher levels of alliance exit.

The models then seem consistent with brinkmanship theory and the relationship between power and risk modeled by Powell (2015). The traumatic events I identified should not help a state's ability to wage conventional conflict but should, in general, diminish a state's capabilities. The fact that those

events are associated with more MID initiation, as opposed to less, precisely in nuclear dyads shows the difference between conflict as a contest of strength (among non-nuclear dyads) and conflict as a risk-taking competition (among nuclear dyads). Finally, the models are consistent with previous empirical evidence that, on average, nuclear dyads are more prone to low-level conflict (Rauchhaus, 2009), which holds across all levels of all traumatic events, one prediction of the Stability-Instability Paradox literature. Except for crises, the models show that traumatic events intensify this effect.

3.7 Conclusion

In this paper, I argued that some traumatic events on the international stage could prompt instability in nuclear dyads. Motivated by Powell's theoretical model (Powell, 2015), I hypothesized that these events could foster instability among nuclear dyads, with traumatic events increasing a state's resolve. Traumatic events generate feedback that leaders are likelier to perceive, given their discrete and salient nature (Hermann, 1990). Due to their negative impacts, they are likely to precipitate loss frames, which makes states more risk-acceptant given loss aversion (Kahneman & Tversky, 1979b). IR scholars have noted that while loss aversion bolsters stability in regular times, it produces instability in situations of sudden declines in a state's security position or when there are misperceptions over the status quo (Jervis, 1992; Levy, 1992, 1996; McDermott, 2004), including instability in the nuclear realm (Berejikian, 2002).

Brinkmanship theory and Powell's theoretical model of the theory investigating the trade-off between power and risk suggest one way loss frames might affect stability between nuclear or non-nuclear dyads (Powell, 2015; Schelling, 2020). Because of nuclear brinkmanship dynamics, disputes among nuclear weapons states are more predominantly contests of resolve and risk-taking, while in other dyads, disputes are classical contests of power. Because of that distinction, traumatic events should make militarized disputes more likely in nuclear dyads, while this effect should differ for non-nuclear dyads. The models presented here largely support these hypotheses.

The empirical models presented here suggest that, except for alliance exit, traumatic events hurt stability among nuclear dyads, with nuclear weapons states more likely to start militarized disputes against other nuclear weapons states after suffering those setbacks on the international stage. The models also show that, in this respect, there is a difference between nuclear and non-nuclear dyads. Among non-nuclear dyads, the effect of traumatic events seems to be the more intuitive, with such setbacks deterring states from attacking most of the time. In the case of alliance exit, its occurrence makes MID initiation less likely for both types of dyads, but the decreasing effect is more moderate for nuclear dyads.

Chapter 4

Nuclear Weapons and Arming after Traumatic Events

4.1 Introduction

How do nuclear weapons change arming decisions? I consider how states react to traumatic events by possibly increasing military burdens and how this dynamic changes once a state has nuclear weapons. The "nuclear substitution hypothesis" posits that nuclear weapons mitigate the guns-butter trade-off (Butt, 2015), providing more cost-efficient defense and moderating arming levels. I consider a possible application of this hypothesis, whether we see this effect after states suffer discrete instances of traumatic events.

The nuclear substitution hypothesis has important implications for the global nuclear nonproliferation agenda. If that hypothesis holds, that provides a powerful reason for states to pursue nuclear weapons. Moreover, if nuclear weapons bring benefits in terms of moderating arming decisions and mitigating arms races, that creates tension between the related goals of nuclear nonproliferation and disarmament on the one hand and general disarmament and prevention of arms races on the other.

I argue that one possible implication of the nuclear substitution hypothesis lies in arming trends after high-impact international shocks, which I call traumatic events. I develop a theoretical argument based on cognitive approaches to consider how traumatic events affect arming decisions. Combining that with the theory behind the nuclear substitution hypothesis, I develop predictions of how nuclear weapons capabilities impact arming decisions after traumatic events, which I investigate through a series of empirical large-N models.

The article proceeds as follows: first, I discuss the literature on arms races and the impact of nuclear weapons on arming decisions, focusing on the nuclear substitution hypothesis. Then, I develop a theoretical argument about how traumatic events can influence changes in foreign policy, drawing from multiple cognitive approaches. From that discussion, I develop some hypotheses about the impact of traumatic events on arming, the impact of nuclear weapons possession on arming after traumatic events, and pos-

sible scope conditions for this nuclear substitution effect. I then build and present empirical models to investigate those hypotheses.

I find that indeed nuclear possession can carry some substitution effects after situations of traumatic events, as some nuclear states tend to arm less than non-nuclear states in those high stress scenarios. However, that is conditioned on how a state operationalize its nuclear arsenal through its nuclear posture. Following Narang (2014)'s typology of nuclear postures, I find that substitution effects after traumatic events are specific to states with "assured retaliation" doctrines, that is, states with clear second-strike capabilities and no envisioned missions beyond nuclear retaliation (that is, no-first use doctrines). Moreover, I also find that satisfaction with the status quo is a scope condition for these substitution effects, as my models suggest it only applies to states without any significant revisionist claims.

4.1.1 Nuclear weapons and arms races

The literature on arms races and armaments considers why states choose to pursue more armaments and the effects of arms races on the likelihood of war. The arms races puzzle is analogous to the war puzzle since, in both instances, states would be better off if they resolved matters diplomatically and not resorted to arms race/war. Integrating domestic and external causes of arms races is interesting because it might illuminate how the former might lead to irrational behavior and produce adverse effects (Glaser, 2000).

In its most basic form, the theory of why states increase arming consists of the "guns versus butter" trade-off (Oren, 1998). Increased military expenditures usually mean less domestic expenditure, which directly affects the population's welfare (Larrosa, 2016). In their respective theoretical models, Powell (1993) predicts, among other things, that risk acceptance by states will increase the levels of arms. In contrast, Oren (1998) predicts that perceptions of hostility by adversaries drive arms races. More recently, Fearon (1998) modeled an interaction on states' arms level under a "war constraint" that imposes a lower bound of arms levels that deters attack even from countries not interested in territorial conquest.

In Fearon (1998)'s model, states within a dyad choose their arms levels considering, first, that arms are costly, but also that those can help with (a) deterring an attack; (b) winning a war as the initiator; and (c) bargaining over issues. He conceptualizes interstate cooperation as the arms levels between the states (higher levels of arms, less cooperation). He defines equilibria as situations where neither states want to spend more in arms given what the other is spending. More arms can increase a state's bargaining position if not matched by the other state, but increased arms levels are wasteful and diminish the value for the state to live with the status quo, making war more likely.

This model has complete information, but if we consider uncertainty about players' profiles, we can see how risk orientation can influence arms-level decisions. Taking the initiative in arming is generally risky because it increases the probability of costly arms races and wars. Therefore, higher levels of risk acceptance by at least one state in the dyad will increase the arms levels of the equilibrium, all else being equal, because those states will be more willing to take a gamble to increase their bargaining position. The question, however, is how nuclear weapons affect that calculus.

An application of the "guns versus butter" trade-off explicitly connected to nuclear weapons is the "nuclear substitution" hypothesis, which posits that nuclear weapons allow states to mitigate the guns

versus butter trade-off and be able to avoid arms races. Butt (2015) argues that this effect is contingent on states being satisfied with the territorial status quo and being able to deal with their security challenges with only nuclear deterrence capabilities. Further, second-strike capabilities greatly increase defensive advantage, which makes lower arms levels more likely (Fearon, 1998). By doing so, nuclear capabilities also reduce uncertainty over whether the state satisfies its war constraint. If the state is uncertain over whether the war constraint is satisfied (as would be the case with most non-nuclear states), the expected value of increased arming would be higher.

In summary, arming beyond basic defensive levels is risky for most states, so changing a state's risk orientation towards riskier behavior will make it more likely to increase arming. Nuclear weapons can provide much more efficient deterrence, being much better able to satisfy Fearon's war constraint and eliminate uncertainty over whether the constraint is satisfied. That means states with nuclear weapons will be less driven to increase military burdens when they become more risk-acceptant. However, there are scope conditions for this dynamic: if a state puts much value on uses of arms levels other than mere defense, such as bargaining over issues or revising the territorial status quo, nuclear weapons will not work as a substitute, as argued by Butt (2015).

4.1.2 Traumatic Events and Foreign Policy

I argue that high-salience, high-impact, events, can cause a sudden and substantial change in a state's assessment of its strategic environment. They are discrete occurrences, easily discerned in a short interval of time, unlike gradual changes such as economic or military decline.

Considering the possible sources of major foreign policy change, Hermann (1990) theorized how "external shocks" are one of the determinants of such changes. He defines "external shocks" as "large events in terms of visibility and immediate impact on the recipient." Based on a cybernetic approach, he argues that these shocks serve as "feedback" that can provoke policy reorientation (Hermann, 1990). In a cybernetic system, agents pursue goals while continuously receiving streams of information through stimuli from the environment ("feedback"), based on which they can change course ("steering"). Hermann argues that most foreign stimuli are too weak to be perceived by decision-makers in a salient way, but external shocks have enough impact to serve as stimuli. More recently, W. R. Thompson (2014) posits a similar role for those external shocks, arguing they can "galvanize policymakers into searching harder for alternative strategies" (W. R. Thompson, 2014).

Hermann (1990) considers three types of "major" foreign policy change: "program change" is a change in the means used for the pursuit of foreign policy goals; "problem/goal change" is a change in foreign policy goals; and "international orientation change," a general reorientation of the country's entire foreign policy, which affects multiple types of decisions.

If states perceive such events as harmful, which I call "traumatic events," they can increase the state's resolve by generating loss frames through loss aversion. Discovered in laboratory settings and formalized by Prospect Theory (Kahneman & Tversky, 1979a), loss aversion is a mechanism by which most actors become more willing to take riskier decisions when facing loss frames, that is, when facing a scenario that is worse than some reference point assumed by the actor (usually presumed to be the status quo). A

more significant willingness to run risks, by definition, translates into increased resolve, especially within a context of brinkmanship and nuclear crises as characterized by risk-taking competition.

Therefore, traumatic events can put states into loss frames, increasing their levels of risk acceptance. Riskier behavior will lead to increased arming beyond basic deterrence levels. However, nuclear weapons can at least mitigate if not completely block that effect since they provide much more efficient deterrence. Because the defensive value of nuclear weapons is more efficient and more certain, states do not need to run risks by increasing arms burdens, even if they are more willing to run risks. From that discussion we can generate our first set of hypotheses:

Hypothesis 1: Non-nuclear weapons states will increase arming after suffering traumatic events;

Hypothesis 2: Possession of nuclear weapons will mitigate the effects of traumatic events on arming decisions;

As an example of this logic for a non-nuclear weapons state, Nicaragua suffered a serious international crisis with Costa Rica in 1978 that led to a regime change, putting Sandinistas in power in coalition with liberal democrats. Just months after that, another severe crisis ensued, this time a territorial dispute with Colombia that lasted over a year, ending in July 1981. In it, Nicaragua left defeated as the U.S. ratified a treaty with Colombia recognizing Colombian sovereignty over the San Andrés Islands, a territory Nicaragua had disputed since the 19th century. By 1985, Nicaragua would more than triple its military burden in comparison to 1978 (Brecher et al., 2021).

As for an example for a nuclear weapons state, Butt (2015) mentions China as possible case of nuclear substitution, with a shift towards lower military burdens after 1979 (it acquired nuclear weapons in 1964), completed by the mid 1980s. In fact, China decreased its military burden by more than half during this period. That was despite China suffering two severe losses in international crises in its conflict with Vietnam, the first in 1978, and the second in 1984. In 1978, China failed to prevent the toppling of a favorable regime in Cambodia, and failed to retaliate against Vietnamese attacks. In 1984, China suffered heavy casualties in a series of border clashes with Vietnam (Brecher et al., 2021).

However, as discussed above, there are scope conditions for this phenomenon. The hypotheses above refer to arming for mostly deterrence/defensive purposes. Two factors seem to determine such scope conditions. First, if states are not satisfied with the international status quo, and wish to revise some issue, then their arming decisions reflect not only a defensive posture but offensive goals. Since nuclear weapons are much less effective for compellence (Sechser & Fuhrmann, 2017), even a state that would resort to nuclear blackmail will find it attractive to also have an edge on conventional capabilities. That follows from what Butt (2015) has found qualitatively in a case study of India. That generates the following hypothesis:

Hypothesis 3: the effects of Hypothesis 2 will be mitigated if the nuclear weapons state has significant revisionist goals

4.2 Research Design

Dependent Variables I use two different measures of arming: the raw value of military expenditures, as measured by Correlates of War (G. e. a. Palmer, 2020; Sarkees & Wayman, 2010), and the ratio of military

expenditures over the country's GDP. Both are on a logarithmic scale. The first reflects actual levels of armaments, while the second reflects military burdens, or how much a country is willing to spend on arms, given the size of its economy. The reason I use military spending as opposed to the overall CINC score, of which military spending is one of the components, is that I believe military spending reflects more directly immediate arrming decisions, as opposed to other components such as population or electricity consumption.

Traumatic Events Many international events could be considered traumatic. However, some, such as sanctions, can have effects other than producing loss frames that would directly impact arming decisions, confusing the analysis here. With that in mind, I consider specifically dissatisfaction with high-salience interstate crises. Given the cognitive argument about loss frames, I considered dissatisfaction with the outcome, as opposed to who was considered to have "won" the crisis. Taking data from the International Crisis Behavior (ICB) dataset (Brecher & Wilkenfeld, 2000a; Brecher et al., 2021), I recorded any crises that: a)were coded as leaving the state dissatisfied, regardless of the level of satisfaction of other states (OUTEVL variable, levels 3 and 4); and b) the gravity of the threat was coded as either "political," "territorial," "threat to influence in the international system or regional subsystem," "grave damage," and "threat to existence" (GRAVITY variable, levels 2 to 6). For the models in this study, I use a normalized count of such events that a state suffered in the preceding five years, making it a continuous variable.

I consider only crises, as opposed to the previous chapters, because the other three types of traumatic events I used in those chapters have features that would confuse the analysis. Beyond its traumatic nature with cognitive effects, they present some more pragmatic, material effects. Sanctions might make arming harder; loss of territory will have direct effects on a state's satisfaction with the status quo, which will confuse our analysis of revisionism; and exit from alliances would bring a material, non-cognitive reason, for more arming. In order to focus on the cognitive dimension of nuclear substitution, I consider only crises where the state left dissatisfied with the outcome, since their material effect on the state's capabilities is not obvious.

Nuclear weapons and doctrines Possession of nuclear weapons might not be enough to explain arming decisions. As I discussed above, for nuclear weapons to produce a substitution effect and mitigate the guns-butter trade-off, they should not merely exist within a country's arsenal. Instead, the country should be able to deploy nuclear weapons to provide effective deterrence, for instance, with second-strike capabilities (Fearon, 2018).

A useful concept here is that of "nuclear posture." (Narang, 2014) defines "nuclear posture" as an overall policy that combines different components (which he identifies not only "capabilities" but also "primary envisioned employment," "command and control architecture," and "levels of transparency") into determining how the state will employ nuclear weapons before and after the initiation of a conflict. Therefore, this concept is apt to distinguish nuclear states in a relevant way for the substitution hypothesis.

Given the discussion above, I include nuclear postures in different model specifications as key IVs to interact with traumatic events. I use Narang (2014)'s coding of regional nuclear postures and their

separation from superpowers. First, Narang considers the United States, the United Kingdom, and the Soviet Union/Russia superpowers in the nuclear realm. For the remaining nuclear powers, whose nuclear strategies reflect regional concerns, Narang identifies three types of nuclear doctrines: "catalytic," "assured retaliation," and "asymmetric escalation."

Summarizing Narang (2014)'s typology: catalytic postures aim to leverage basic nuclear capabilities to catalyze third-party support in a conflict. That requires only the ability to assemble some nuclear weapons, which means that they are not readily operational in the early stages of conflict (Israel from 1967 to 1990, South Africa while it had nuclear weapons from 1979 to 1991, and Pakistan from 1986 to 1997); "assured retaliation" postures aim the retaliation of nuclear attacks through second-strike capabilities (China and India through all their nuclear histories, and Israel from 1991 to now); and "asymmetric escalation" postures aim nuclear first-use options to use nuclear weapons as a deterrent against conventional military challenges (France through all its nuclear history, and Pakistan since 1998).

Revisionist states I operationalize revisionism using the Issue Correlates of War (ICOW) dataset (Frederick et al., 2017). I would code the state as revisionist in a given year if it had an active challenge against another state on an issue coded as "high salience" by ICOW. I include this variable as a control in models testing Hypotheses 1 and 2 and use it for models testing Hypothesis 3 to create a variable that categorizes states as "non-nuclear," "nuclear revisionist," and "nuclear status quo."

Controlling for local arming trends A particular control variable merits special attention. States make arming decisions in great part in response to arming by their peers: for major powers, other major powers; for other states, their proximate neighbors. This point is important because it determines the basic deterrence levels of arming we would expect regardless of nuclear status or traumatic events.

Therefore, I build measurements of arming trends by subregion (or major power status). I divide countries by the 17 subregions of the United Nations geoscheme, with major powers constituting their own group. Then, for each region, I use a Generalized Additive Model (GAM) to regress military expenditures or military burdens by year, producing yearly trends of these values per region.

Other controls As additional control variables, I include four variables from Varieties of Democracy (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, Altman, Bernhard, Cornell, Fish, et al., 2021a): their continuous measure for liberal democracy; a dummy for the prevalence of nationalist ideology; a dummy measuring the prevalence of military support for the country's regime; and the "military dimension index," a continuous variable estimating to what extent the regime's power base depends on the military. I also include two dummy variables from the Alliance Treaty Obligations and Provisions (ATOP) dataset (Leeds et al., 2002b): one each for whether the country is in a defensive or offensive alliance that year (lagged one year). I also include a continuous variable measuring territorial threats, lagged one year, measured by Gibler (2012). Finally, I include GDP as a control for the models where the response variable is military spending.

Data and Methods My data comprise a sample of 3660 country-years from 1960 to 2001. Of these, 243 observations are of nuclear weapons states, 38 of which are revisionist states according to my coding, and 146 have nuclear rivals. There are 318 cases of dissatisfaction in high salience in international crises.

4.3 Analysis

I run a series of Generalized Linear Models (GLM). I include lagged versions of the dependent variable so I can account for temporal correlation. I use lags of five years, which makes more sense given the slower nature of decisions in military spending. Military spending is close to normal, so I use a Gaussian distribution for those models. Military burden has a right skew in its distribution, so I use the gamma distribution with a log link function.

In order to investigate my hypotheses, I run a total of eight models with different specifications. To investigate Hypotheses 1 and 2, I run models with two different interaction terms with the crises variable: a dummy separating nuclear and non-nuclear states; and a categorical variable dividing further nuclear weapons states according to their respective nuclear doctrines, as coded by Narang (2014) and explained above. Running each of these specifications for my two response variables yields four models to investigate Hypotheses 1 and 2. Finally, I investigate Hypotheses 3 interacting the crises variable combining information on nuclear status and revisionism.

Non-Nuclear Weapon States and the effect of Crises

Table 4.1 shows results for all models.The models show a positive effect of crises on both arming trends and military burden trends. However, that effect is significant in the 95% confidence interval only to predict military spending, not military burdens. Figure4.1 shows coefficient plots for the independent term of this variable. Models 1, 2, and 5, have military spending as the dependent variable, while Models 3, 4, and 6, have military burdens as the dependent variable. I also plot coefficient estimates for the the regional trend variables I built and described above.We can see how regional arming trends influence arming decisions and how important it is to control for them.

Given the interaction terms in all models, these results provide evidence for Hypothesis 1: On average non-nuclear states have larger trends on military spending and military burdens if they suffered losses in high-salience international crises in the previous five years, although evidence is weak with respect to military burdens. Using as reference the models that interact crises with the simple nuclear status dummy, non-nuclear states that have suffered extreme values of crisis incidence spend 6.5% more in the military and run military burdens 11.9% larger than non-nuclear states that have suffered minimal values of crises, on average and all else being equal.

Nuclear and Non-Nuclear States after Traumatic Events

To investigate how nuclear status can influence the effects of international crises on arming decisions, we can consider two measures in the models. One is the difference in marginal effects across nuclear status

Table 4.1: Model Results

	Dependent variable:					
	Military Spending		Military Burden		Military Spending	Military Burden
	normal		*glm: Gamma link = log*		*normal*	*glm: Gamma link = log*
	(1)	(2)	(3)	(4)	(5)	(6)
Dissatisfaction in Past Crises	0.104**	0.112**	0.023	0.029	0.103**	0.023
	(0.045)	(0.045)	(0.018)	(0.019)	(0.045)	(0.018)
Nuclear Weapon	0.308***		0.085***			
	(0.061)		(0.025)			
Nuclear Major Power		0.254***		0.069*		
		(0.097)		(0.040)		
Asymmetric Escalation Posture		0.212*		0.103**		
		(0.124)		(0.051)		
Catalytic Posture		0.587***		0.171***		
		(0.121)		(0.050)		
Assured Retaliation Posture		0.281***		0.111***		
		(0.104)		(0.043)		
Nuclear Revisionist State					0.286*	0.047
					(0.156)	(0.064)
Nuclear Status Quo State					0.312***	0.090***
					(0.063)	(0.026)
Military Spending Lag (5 years)	0.652***	0.647***			0.652***	
	(0.009)	(0.009)			(0.009)	
GDP	0.339***	0.349***			0.338***	
	(0.013)	(0.013)			(0.013)	
Regional Trend (Military Spending)	0.074***	0.079***			0.075***	
	(0.008)	(0.008)			(0.008)	
Military Burden Lag (5 years)			0.362***	0.361***		0.364***
			(0.006)	(0.006)		(0.006)
Regional Trend (Military Burden)			0.158***	0.161***		0.152***
			(0.010)	(0.010)		(0.010)
Revisionist Claim	−0.029	−0.038	0.056***	0.055***		
	(0.042)	(0.042)	(0.018)	(0.018)		
Democracy	−0.189***	−0.237***	−0.033*	−0.041**	−0.197***	−0.026
	(0.048)	(0.049)	(0.018)	(0.019)	(0.048)	(0.018)
Nationalism	0.074**	0.048	−0.008	−0.013	0.069**	−0.010
	(0.029)	(0.030)	(0.012)	(0.012)	(0.029)	(0.012)
Military Remuneration	0.014	0.010	0.013**	0.013**	0.013	0.013**
	(0.013)	(0.013)	(0.005)	(0.005)	(0.013)	(0.005)
Military Support for Government	0.065**	0.055*	0.027**	0.025**	0.063**	0.036***
	(0.029)	(0.029)	(0.012)	(0.012)	(0.028)	(0.012)
Territorial Threat	0.326	0.483	0.312**	0.319**	0.330	0.307**
	(0.321)	(0.324)	(0.133)	(0.134)	(0.321)	(0.134)
Defensive Alliance	−0.036	−0.020	−0.021*	−0.016	−0.042	−0.013
	(0.026)	(0.027)	(0.011)	(0.011)	(0.026)	(0.011)
Offensive Alliance	0.725***	0.697***	−0.010	−0.014	0.724***	−0.013
	(0.102)	(0.102)	(0.043)	(0.043)	(0.102)	(0.043)
Interaction Crises:Nuclear Weapon	−0.347**		−0.082			
	(0.150)		(0.062)			
Interaction Crises:Major Power		−0.075		0.019		
		(0.229)		(0.096)		
Interaction Crises:Asymmetric Escalation		−0.457		−0.055		
		(0.705)		(0.295)		
Interaction Crises:Catalytic		−0.215		−0.141		
		(0.237)		(0.099)		
Interaction Crises:Assured Retaliation		−1.541***		−0.394***		
		(0.353)		(0.147)		
Interaction Crises:Nuclear Revisionist					0.038	0.121

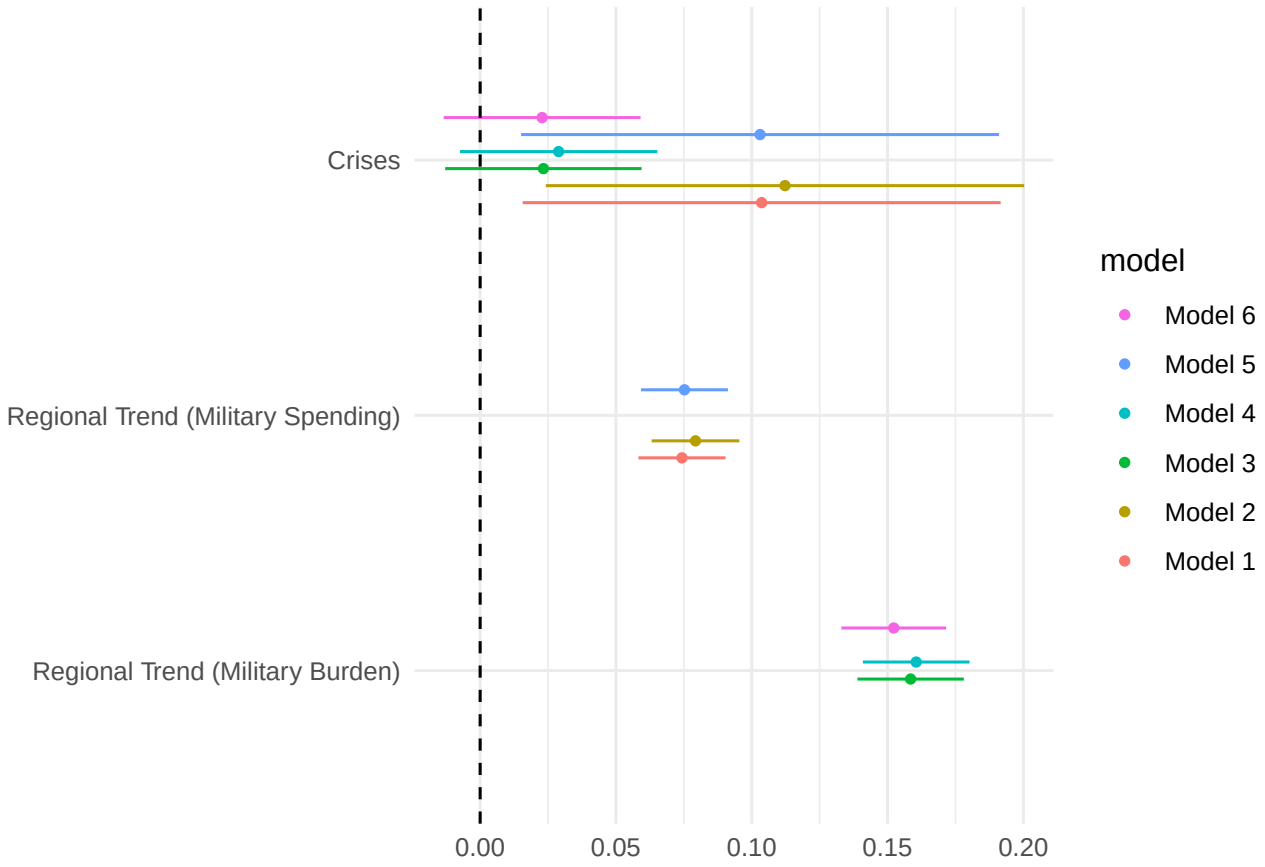

Figure 4.1: Coefficient Plots

changes. That is, the effects of crises on arming have different trends between nuclear and non-nuclear states. The other way is to compare the expected arming levels of these groups and how that comparison changes at different levels of crises.

We can start this analysis by looking at coefficient plots for the relevant terms. Figure4.2 plots coefficients of the independent terms for nuclear status, along with their interaction terms with crises. Remember, there are two different specifications of nuclear status, which are shown separately in each panel of the figure. The first is a simple dummy dividing states by whether they have nuclear weapons. The second divides nuclear weapons states by nuclear doctrine. All those estimates contrast non-nuclear states, which serve as the reference category for all those variables. The top dot and whisker refer to the model with military spending as the response variable for each variable. In contrast, the bottom one refers to the model with military burden as the response variable.

Before we look into the interaction with crises, let us first consider the estimates for the independent terms, which account for arming decisions of nuclear states in the absence of recent crises. In those scenarios, on average, nuclear weapons states spend more on the military and sustain higher military burdens, both estimates being significant in the 95% confidence level. In the absence of crises, nuclear states spend 31.9% more with the military and run 9.7% higher military burdens than non-nuclear states, on average and all else equal.

Now I consider the interaction terms to investigate differences in the effect of crises according to nuclear status. With the dummy variable, there is good evidence that nuclear possession mitigates the effects of crises on military spending, as the estimate for the interaction term is negative within a 95% confidence interval. With less confidence there is also a mitigating effect for military burdens.

Things get clearer once I break down the doctrines, as we can see that this pattern is true in particular for nuclear states with "assured retaliation" doctrines, as this is the only doctrine whose interaction with crises produced an estimate significant in the 95% confidence level (now for both military spending and burdens).

After checking the interaction terms, I plot predicted outcomes to capture better the effects of crises on arming per nuclear type. Plots are in Figure 4.3. Generally, at low levels of past crises, states with catalytic nuclear postures are the only with substantially higher arming trends than non-nuclear states. At high levels of traumatic events, however, there is a clear discrepancy between states with assured retaliation and all other types, with the former presenting much lower arming trends. At extreme levels of past crises where the states was dissatisfied with the outcome, states with assured retaliation doctrines spend 70.9% less and sustain military burdens 60.7% lower than non-nuclear states. Meanwhile, states with other nuclear postures did not show substantial differences from non-nuclear states, and, again, the interaction terms for those did not reach desired confidence levels.

Nuclear revisionists

Now I investigate Hypothesis 3 considering whether there are scope conditions for the impact of nuclear weapons on arming decisions after crises. Figure4.4 plots coefficients for the independent and interaction terms of the key independent variables. The independent terms follow the abovementioned patterns,

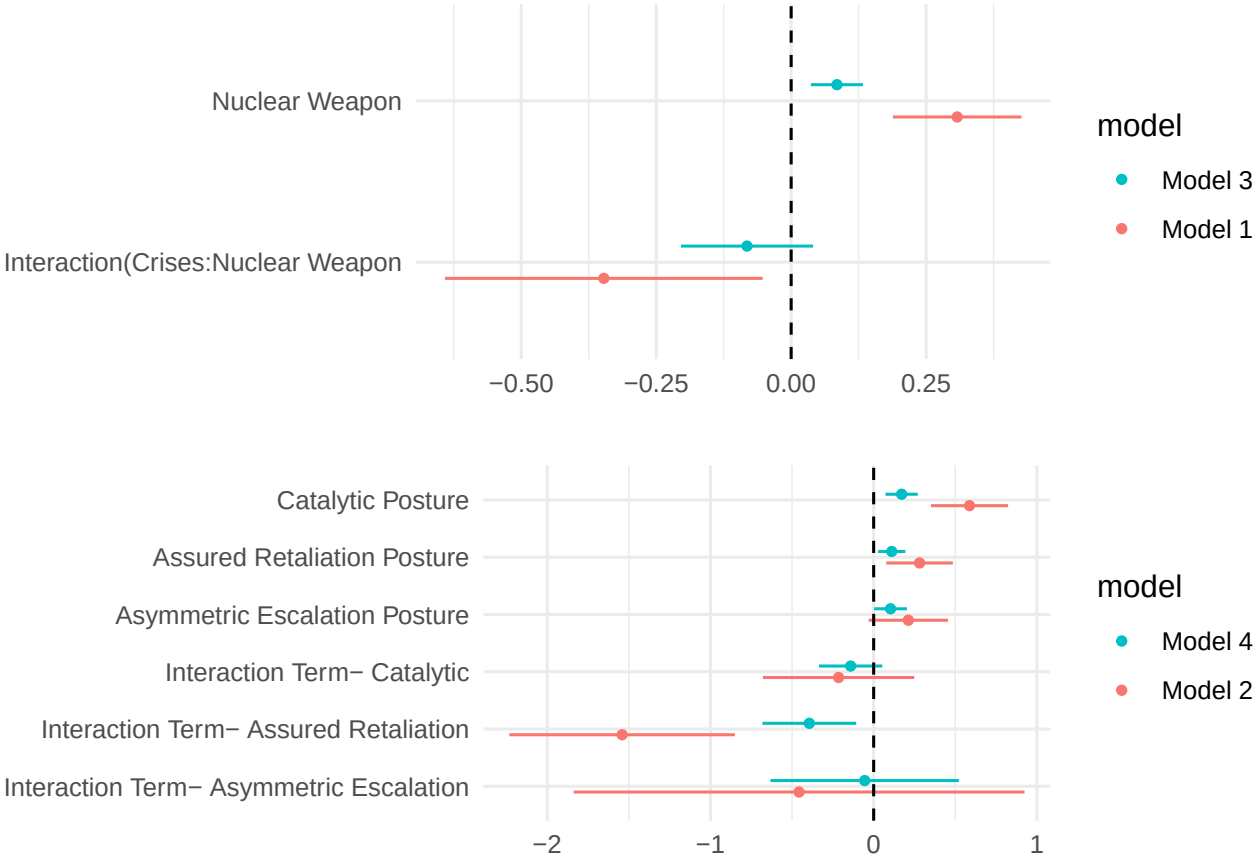

Figure 4.2: Coefficient Plots

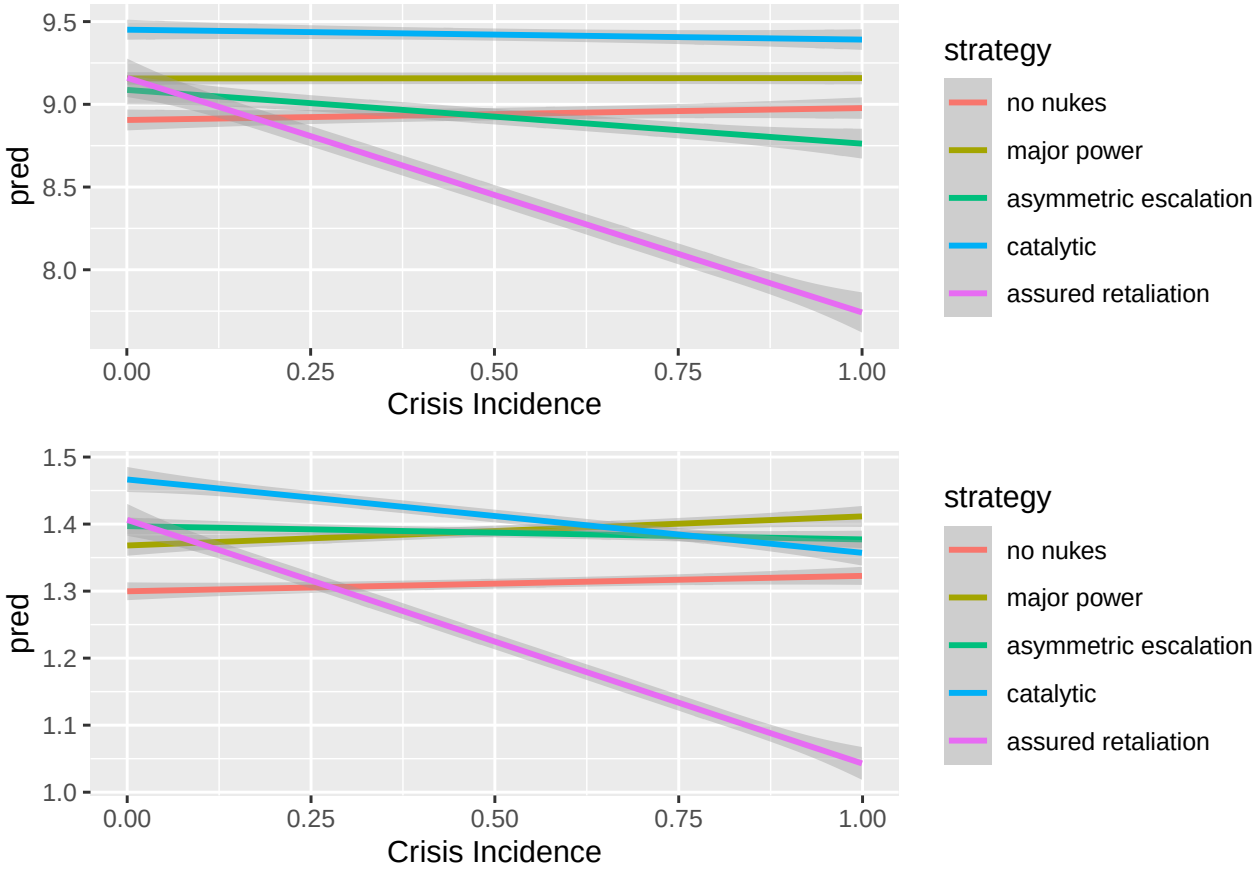

Figure 4.3: Predicted Outcomes

where nuclear states spend usually more with the military in the absence of crises and sustain higher military burdens.

Looking at the interaction terms, we can see another scope condition for the nuclear substitution effect, consistent with Hypothesis 3. The estimates for the interaction terms with nuclear status quo states (that is, nuclear states with no significant revisionist claims) are negative and significant, in the 95% confidence level for predicting military spending, and in the 90% confidence level for predicting military burdens. Meanwhile, estimates for the interaction with nuclear revisionist states do not reach desired confidence levels (and the estimates are positive). This suggests that the nuclear substitution effect after crises is only relevant when nuclear states do not have revisionist intents.

Figure4.5 plots predicted outcomes for these models. With respect to military spending patterns, nuclear revisionists and nuclear status quo states have similar arming patterns, higher than non-nuclear states, in the absence of recent traumatic events. At the highest levels of those, nuclear status quo and revisionist states come apart in their expected military spending, with the former becoming statistically similar to non-nuclear states, and the latter maintaining higher spending patterns.

Oddly enough, in the absence of traumatic events, nuclear status quo states sustain higher military burdens on average, while nuclear revisionist states sustain similar burdens to non-nuclear states. As setbacks happen, however, the discrepancy in the effect for nuclear status quo states is clear. At extreme levels of past crises where the state was dissatisfied with the outcome, nuclear status quo states sustain military burdens 18.4% lower than non-nuclear states. Predicted outcomes for nuclear revisionist states are even higher than non-nuclear states, although, again, the interaction term here was not significant in desired confidence intervals. Either way, this shows the nuclear substitution effect seems to apply only when the nuclear states does not have any significant revisionist claim.

4.3.1 Discussion

The models provide evidence that traumatic events, such as dissatisfaction in high-salience international crises, tend to increase arming for non-nuclear states and that nuclear possession reverses this trend, provided some other conditions. That seems to corroborate a more nuanced interpretation of the substitution hypothesis: although nuclear weapons states run higher military burdens in typical scenarios, some of them are less reactive to traumatic events that could lead them to increased arming.

The models showed that more important than having nuclear weapons is what states do with them, more specifically through their nuclear postures. Assured retaliation postures were the only ones to provide clear "substitution hypothesis" benefits with respect to both military spending and military burdens. This kind of posture makes explicit use of nuclear capabilities and is more strictly defensive, focusing on keeping second-strike capabilities for a retaliatory strike. As Narang (2014) explains, given the natural uncertainty about military capabilities, states that employ assured retaliation doctrines are transparent about their nuclear capabilities (for deterrent purposes). However, they are ambiguous about their deployment (to enhance survivability). That makes it relatively cheap to deter since nuclear adversaries do not have complete certainty about second-strike capabilities. That means that assured retaliation makes direct use

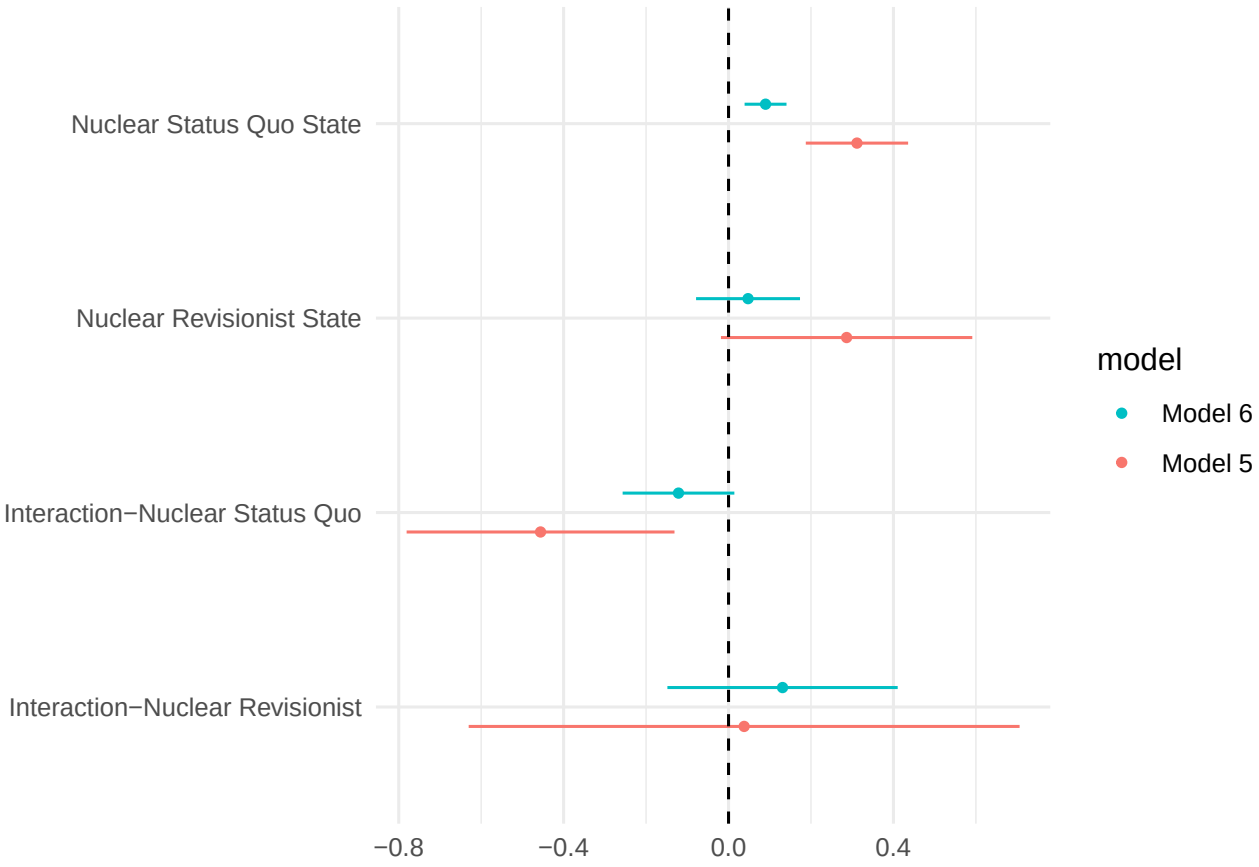

Figure 4.4: Coefficient Plots

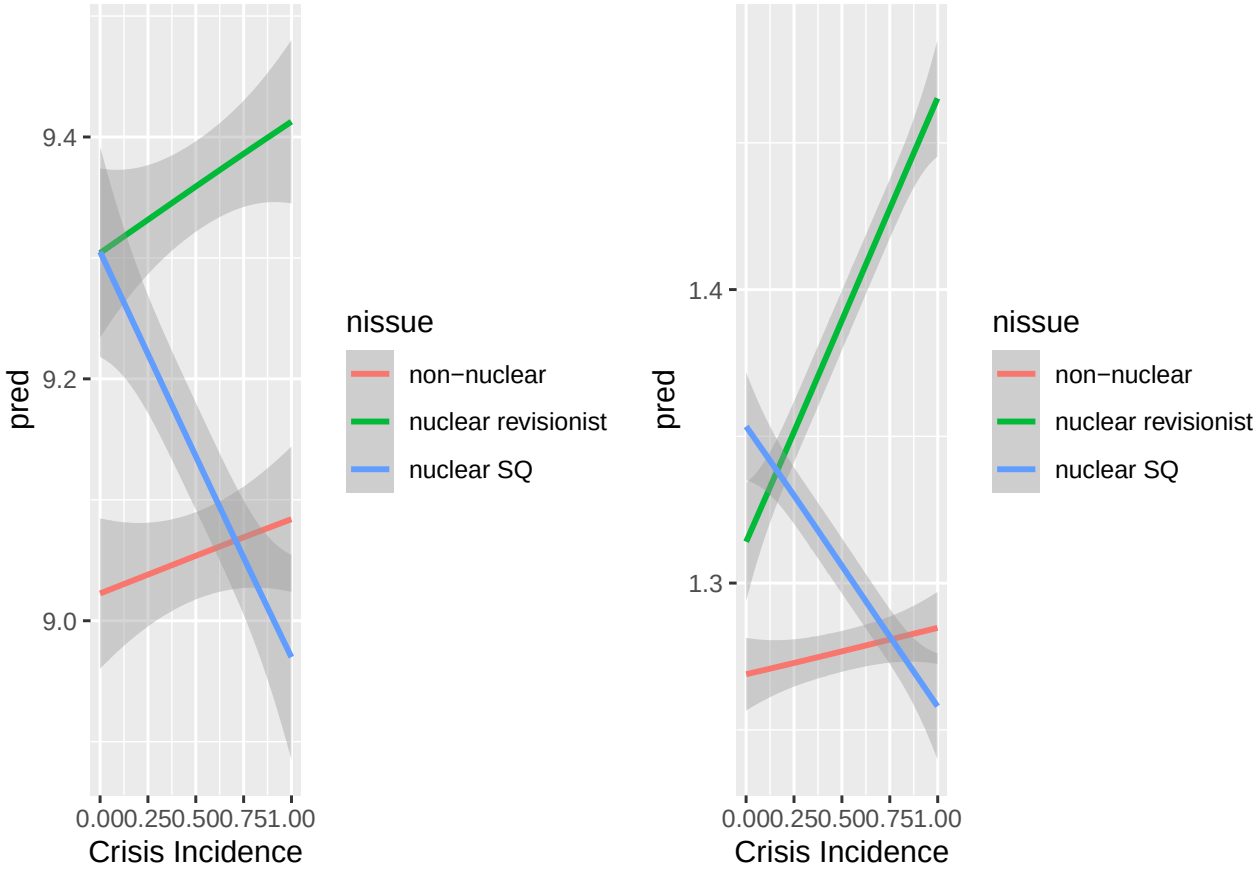

Figure 4.5: Predicted Outcomes

of nuclear weapons to deter (unlike catalytic postures) but in a more cost-effective way than asymmetric escalation doctrines.

I also considered possible scope conditions for substitution effects that go beyond the nature of nuclear capabilities. Considering revisionism in international issues, the models show evidence that this is true. In situations of great stress, after multiple high-level international crises feeling dissatisfied with the outcomes, nuclear states would sustain lower military burdens trends than non-nuclear states if they did not have any significant revisionist claims. Meanwhile, the same could not be established for nuclear revisionist states.

In summary, the models I presented here show some evidence for nuclear substitution in the context of traumatic events, given some important conditions. Those events can lead to higher arming, but nuclear weapons could work to prevent this trend. That means that nuclear weapons can make states less reactive to degrading changes in their international environment in a way that would lead them to increase arming levels. However, how states operationalize their nuclear capabilities is also important. For states to generate substitution effects after traumatic events, they need to be able to actually use (or threaten to use) nuclear weapons early in the conflict (excluding purely catalytic postures) while at the same time keeping the array of uses at a minimum, limiting employment to retaliatory strikes after absorbing a nuclear first strike. Likewise, the existence of revisionist claims probably condition the existence of nuclear substitution effects as well, with absence of such revisionist claims as a scope condition for the effect.

4.4 Conclusion

In this study, I presented empirical models of arming decisions over time after traumatic events among nuclear and non-nuclear states to investigate possible applications of the nuclear substitution hypothesis. I developed an event-based theoretical argument following cognitive approaches to posit how traumatic events can lead to higher arming. Following implications of the nuclear substitution hypothesis, nuclear weapons states feel less the effects of traumatic events on arming. However, there are scope conditions for these effects.

The nuclear substitution hypothesis posits that nuclear weapons capabilities can mitigate the guns-butter trade-off, leading states with those capabilities to spend less on arming than states without those capabilities in similar environments. Following cognitive approaches, I argued that the years after suffering traumatic events could be one scenario where we can see the effects of nuclear substitution differentiating nuclear and non-nuclear states.

Traumatic events can provide positive feedback to leaders and governments, changing their evaluation of the state's international position. Due to their harmful nature, they precipitate loss frames, making those states more willing to make riskier decisions, such as increased arming. However, if nuclear weapons can provide more cost-effective security benefits (at least for defensive purposes), even higher risk acceptance will not necessarily lead to increased arming. So we should see differences in arming trends after traumatic events according to nuclear capabilities as an example of nuclear substitution effects.

The empirical models I presented in this study provide some evidence of nuclear substitution effects after traumatic events. I consider one specific type of traumatic event, dissatisfaction in high-salience international crises. After such crises, non-nuclear states tend to increase their arming in total military expenditures and as a proportion of their economy. Meanwhile, some nuclear weapons states can reap benefits from the nuclear substitution effect, as in post-traumatic events scenarios they arm themselves less than non-nuclear states. However, that is conditioned on how nuclear states operationalize their nuclear arsenal: states need to have clear second-strike capabilities, and no intended uses besides nuclear retaliation (that is, no-first use). Absent the former (as in states with catalytic postures), states cannot credibly use their nuclear weapons as a deterrent; and missions going beyond retaliation (that is, first use doctrines) require much more military resources than simply sustaining a retaliatory second-strike mission.

Following some implications on why states arm themselves, along with the primarily deterrent/defensive uses of nuclear weapons, some models considered the role of revisionism as possibly mitigating nuclear substitution effects. The models showed some evidence for that, as substitution effects seem restricted to status quo states, that is, states with significant revisionist claims.

Finally, this study has some limitations that merit further investigation. First, I considered only one type of traumatic event. Further studies should consider whether different traumatic events produce similar effects, which might require disentangling contradicting effects coming from the same event. Second, given sampling limitations, the models testing possible scope conditions of revisionism could not include stratification by nuclear posture types. Investigating how nuclear doctrines interact with such factors might require different methods, possibly including qualitative ones.

This study aimed to test some implications of the nuclear substitution hypothesis, providing some empirical insights on the potential benefit of nuclear weapons possession and the scope conditions for this benefit. That has obvious implications for the international nonproliferation agenda, as it might put tension in the goals of preventing nuclear proliferation and promoting general disarmament.

Chapter 5

Conclusion

In this dissertation, I conducted three different studies covering one overarching question: how traumatic events and nuclear weapons interact in foreign policy behavior? Through the lens of cognitive approaches and the nuclear politics literature, I identified some traumatic events, built and discussed empirical models that investigate different aspects of the nuclear politics literature. The studies find that traumatic events are useful both to understand changes in nuclear weapons decision-making and to understand how nuclear weapons change foreign policy behavior.

The articles in this dissertation have found, first, that traumatic events are useful in predicting changes in foreign policy behavior. Besides considering variables that reflect indicators such as military power, agreement between states, or economic measures, statistical studies should consider including discrete events in their models. The relevance of events to policy changes, sometimes dramatic ones, is very established in historical treatments and case studies, but not as much in quantitative studies.

More directly related to the primary goal of this dissertation, the studies I conducted here show how states perceive nuclear weapons and how nuclear weapons change their behavior, under the lens of traumatic events. In particular, the articles here investigated how traumatic events affect decisions to pursue nuclear weapons, and how foreign policy behavior after traumatic events differs according to whether states have nuclear weapons or not.

In the first article, I investigated the potential impact of traumatic events on nuclear pursuit. My empirical models found that traumatic events can precipitate the onset of nuclear weapons programs. Moreover, countries that are more open to freedom of expression are more vulnerable to this dynamic, an interesting finding that merits further investigation. Following Debs and Monteiro (2017b)'s model of security-based nuclear proliferation, the study showed how traumatic events could help a state's willingness constraint to pursue nuclear weapons through a salient reevaluation of its security position.

In the second article, I investigated how the differences in conflict stability after traumatic events according to whether the states involved in the potential conflict have nuclear weapons or not. My models found that states are more likely to initiate militarized interstate disputes after traumatic events when they are in a strict nuclear dyad, that is, when both they and their potential targets have nuclear weapons. This seems to follow from implications of Schelling's brinkmanship theory (Powell, 1988, 2015; Schelling,

2020), which posits that conflict between nuclear weapons states becomes more a contest of resolve, or risk taking, as opposed to a contest of military strength. Following Prospect Theory (Kahneman & Tversky, 1979b), traumatic events can precipitate loss frames, increasing a state's risk acceptance. In strict nuclear dyads, that means those states will be more likely to initiate militarized conflict in a more prevalent way than in non-nuclear dyads, given the postulates of brinkmanship theory about the role of resolve.

Finally, in the third and last article, I investigated differences in arming decisions after traumatic events between states with and without nuclear weapons. My models found that nuclear weapon states are less prone to increasing arms burdens after traumatic events than non-nuclear weapon states. Therefore they provided some evidence for the nuclear substitution hypothesis (Butt, 2015), showing that states see nuclear weapons beneficial in not requiring increased arming burdens. However, the models also found that this pattern is conditional on other factors. First, nuclear postures matter (Narang, 2013): in order for states to reap the benefits of substitution, they need on one hand to have nuclear weapons that are ready for use once a crisis emerges, while at the other their posture cannot be so expansive in their intended uses that would require larger burdens. In summary, it is better in this regard for states to have both second-strike capabilities and no-first use policies. Second, revisionist states do not reap the benefits of substitution, given their expansionist aims and even possible intents of using nuclear weapons for compellence, a much more complex task than deterrence (Sechser & Fuhrmann, 2017).

We can think of the following research implications of the studies in this dissertation. First, events matter, not just in case studies, but in quantitative studies as well. As I did here, cognitive approaches, such as cybernetic theory (Hermann, 1990) and prospect theory (Kahneman & Tversky, 1979b), can provide a generalized understanding of how events can influence state behavior, that could in turn motivate empirical models of such behaviors. With respect to nuclear politics, this implication is more clear in the first article, showing how certain events can precipitate nuclear pursuit.

Second, nuclear weapons matter, even if their actual use is extremely rare. Nuclear weapons change states' perceptions of their position in the international system, changing how they react to significant shocks such the traumatic events I identified in this dissertation. The second and third articles show this implication. On one hand, the second article shows how nuclear weapons can be damaging to conflict stability and result in more militarized conflict. On the other hand, the third article showed that nuclear weapons, under certain conditions, can bring benefits to states by making them to feel more secure such as to not react to traumatic events with increased arming.

Both of these conclusions can find ground on brinkmanship theory (Powell, 1988, 2015; Schelling, 2020), showing its relevance for the understanding of how nuclear weapons change foreign policy behavior and international interactions. If conflict among nuclear states becomes more a contest of resolve or risk taking, then that can create instability among nuclear dyads, as states would be more likely to start militarized conflict even if they perceive themselves weaker than their adversary (such as after suffering traumatic events). Moreover, if the balance of military strength is not as relevant once a state has nuclear weapons, they can provide for proper defense without demanding high arming burdens, even after moments of weakening security positions.

We can also think of some policy implications of this dissertation. First, the first and second articles show how the presence of nuclear weapons in the world bring more possibilities of dire of consequences of traumatic events, as those articles showed in the cases of start of nuclear weapons programs and militarized conflict. Second, the third article shows an important benefit of nuclear weapons that creates a tension between two close goals of the international community: that of nuclear disarmament and nonproliferation on one hand, and that of conventional arms disarmament and the prevention of arms races on the other. In order to realistically pursue the nuclear disarmament and nonproliferation agenda, the international community needs to account for this tension.

Finally, I consider some limitations of my research along with prospects for going forward with this line of study. The major issues revolve around my selection of traumatic events. First, traumatic events are not created equal. Some might have extra effects that can confuse the analysis. That is reflected in the third article, where for that reason I opted to use only one type of traumatic events, as opposed to the four in the first and second articles. That means that, although traumatic events can be useful as a general concept, their inclusion in empirical models must take into account the specific nature of each type of event. Moreover, for reasons of scope of the study, I only considered international traumatic events, that is, events flowing from international interactions. That is an important limitation because one could expect that traumatic events flowing from domestic politics would have similar effects as international traumatic events. That is an important prospective development going forward, which requires not only new work in data collection and empirical analysis, but also on further theoretical work.

Appendix A

ROC/AUC for Chapter 2 Models

Figure A.1 shows ROC curves for the standard log-logistic models and split-population models side by side. As one can see comparing the curves, the addition of the risk equation in the split-population model provides a big improvement in predictive accuracy, compared to the standard models. That is true across all specifications with the different key independent variables. Table A.1 shows the AUC for these curves. These values range from 0.781 to 0.798 for the standard models, and from 0.91 to 0.953 for the split population models. The split population model with the count of traumatic events has the bigger AUC estimate.

Figure A.2 shows ROC curves for models testing Hypothesis 2. Once more we can see a clear improvement of predictive accuracy with the split population models. Table A.2 shows AUC estimates. They range from 0.781 to 0.798 for regular models and from 0.901 to 0.968 for the split population models. Here the split population model with territory loss has the largest AUC estimate.

Table A.1: AUC for Hypothesis 1 Models

Key IV	Regular Model	Split Population Model
Trauma Count	0.781869	0.9536243
Trauma Dummy	0.7940157	0.9468065
Sanctions	0.7896423	0.9494287
Crisis Loss	0.7983518	0.9425080
Territory Loss	0.7952426	0.9186177
Alliance Exit	0.7987076	0.9407754

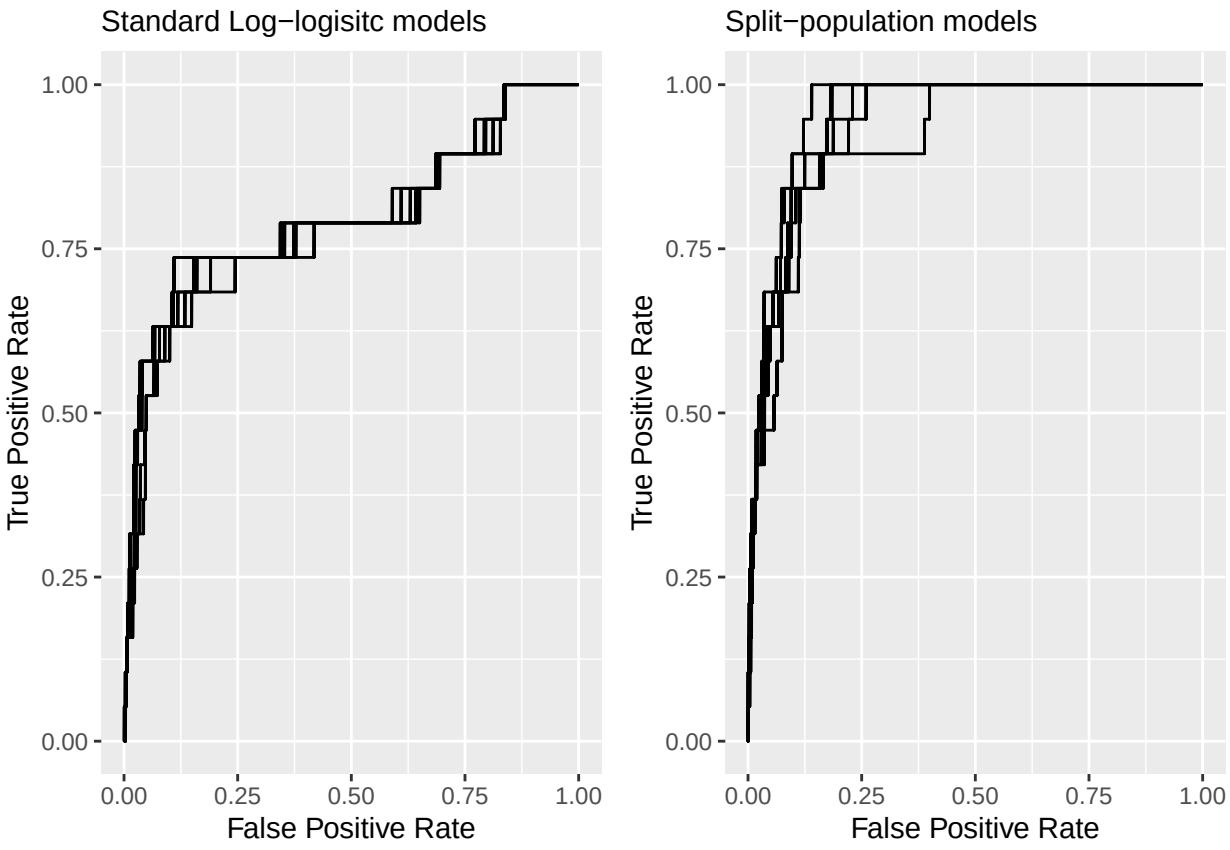

Figure A.1: ROC Curves, Hypothesis 1

Table A.2: AUC for Hypothesis 2 Models

Key IV	Regular Model	Split Population Model
Trauma Count	0.7818693	0.9512175
Trauma Dummy	0.7940157	0.9237404
Sanctions	0.7896423	0.9516014
Crisis Loss	0.7983518	0.8968814
Territory Loss	0.7952426	0.9673722
Alliance Exit	0.7987076	0.9412156

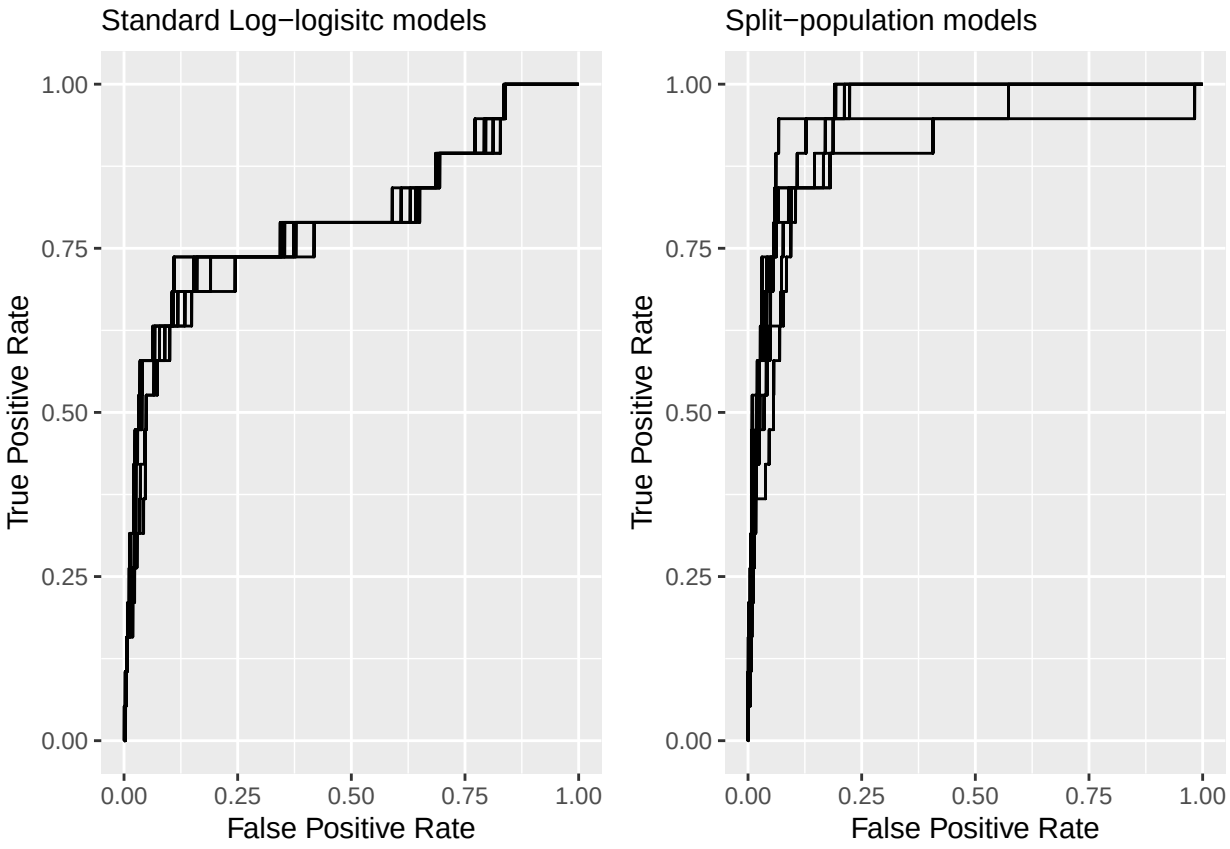

Figure A.2: ROC Curves, Hypothesis 2

Appendix B

Chapter 2- Models with all Traumatic Events

Below I show results from models that include all individual traumatic events as covariates together. That serves as a robustness check for the models in the main text, where each model had just one of those events. B.1 and B.2 show results for Hypothesis 1 (Cox models and split-population models, respectively). We can see that the results are predominantly similar to the models in the main text, although territory loss loses significance in the 95% level in the split-population model.

Table B.1: Results for Cox Models- Hypothesis 1 (All Traumatic Events)

	Nuclear Weapons Pursuit
Traumatic Events(Count)	1.530^{*}
	(0.870)
Traumatic Events(Dummy)	-0.821
	(1.424)
Sanctions	2.412^{**}
	(0.948)
Crisis Loss	0.914
	(1.362)
Territory Loss	1.619^{**}
	(0.662)
Alliance Exit	0.339^{***}
	(0.108)
Nuclear Exploration	-1.503^{**}
	(0.762)
Past MIDs	-1.771
	(1.151)
NPT Ratification(no-P5)	0.585^{***}
	(0.203)
NPT Era	-0.476
	(0.342)
Nuclear Technical Capabilities	-4.650^{**}
	(1.951)
GDP per capita(log)	1.676
	(1.181)
Policy Similarity with System Leader	-4.342^{**}
	(2.047)
Nationalism	0.139
	(0.085)
Freedom of Information	0.689
	(0.661)
Observations	5,639
Notes:	$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Table B.2: Split-population Models- Hypothesis 1 (All Traumatic Events

	Nuclear Weapons Pursuit
Traumatic Events(Count)|Duration	3.081**
	(1.304)
Traumatic Events(Dummy)|Duration	0.135
	(1.880)
Sanctions|Duration	0.226**
	(0.107)
Crisis Loss|Duration	−16.224***
	(1.142)
Territory Loss|Duration	−1.651
	(1.459)
Alliance Exit|Duration	0.636***
	(0.193)
Nuclear Exploration|Duration	−0.732**
	(0.354)
Past MIDs|Duration	−3.346*
	(1.740)
NPT Ratification(no-P5)|Duration	0.965
	(1.205)
NPT Era|Duration	−4.448**
	(2.076)
Nuclear Capabilities|Duration	0.147*
	(0.089)
GDP per capita(log)|Duration	0.429
	(0.448)
Policy Similarity with System Leader|Duration	
	(0.000)
Nationalism|Duration	−0.320
	(13,295.350)
Freedom of Information|Duration	1.750
	(2.381)
Polity|Duration	−0.024
	(0.509)
Nuclear Ally|Duration	
	(0.000)
Intercept|Duration	1.494
	(25,997.170)
Log(alpha)	−1.526
	(2.038)
Intercept|Risk	
	(0.000)
Past MIDs|Risk	0.762
	(13,295.350)
Nuclear Capabilities|Duration	
	(0.000)
Observations	5,639
Notes:	***p < .01; **p < .05; *p < .1

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