Explaining the Path and Pace of Nuclear Weapons Programs

by

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ABSTRACT

This dissertation explores two key questions related to nuclear weapons programs: First, under what conditions do states decide to start nuclear weapons programs? And second, once states begin such programs, when and why do they vary the path and pace of their nuclear development?

A state's wealth and resources, and willingness to make the political decision to begin a nuclear weapons program, determine whether a government will decide to start down the path to nuclear weapons. Past scholarship has identified several different possible factors that increase a state's risk of making the decision to start such a program. Using event history analysis, and including every country in the world starting in 1939, I demonstrate that elements of the security environment - particularly whether a state has a nuclear strategic rival - and prior nuclear reactor experience have the greatest effect on a state's decision to start a program.

Once a state begins a nuclear weapons program, what affects the path and pace of that program? I offer two main theories regarding this question and make the first scholarly attempt to model the paths of all nuclear weapons programs that have ever existed. I use event history models to conduct the statistical analysis.

The models confirm both theories: First, the weaker a state's civilian control over the military is, the less likely a state will be to accelerate the pace of its program. Second, the more independent a state's nuclear bureaucracy is, the more likely a state will be to

accelerate its nuclear weapons program. Finally, I explore the mechanisms underlying these theories in three historical case studies.

CHAPTER 1

Introduction

The path and pace of nuclear weapons programs vary widely across countries. Not all governments have the capability and the political will to start a nuclear weapons program. Of those that do, there is no set path to take once a program has begun. Nuclear weapons programs experience periods of acceleration or deceleration, and some are shut down entirely. Why do some states start nuclear weapons programs? Once they start, why do they vary the path and pace of their nuclear development? What accounts for the differences?

A state's external security environment can affect that state's decision to pursue a nuclear weapons program. Facing a major security threat increases the state's likelihood of deciding to pursue such a program. However, once that program has begun, the state may make many different types of decisions regarding the nature and use of the program. The path a state takes as it pursues and develops nuclear weapons is lined with what I term pace decisions: decisions to accelerate, or decelerate, the program. These decisions can redefine a nuclear weapons program. In this dissertation, I analyze acceleration decisions.

When, and why, a government decides to accelerate a program is much less dependent on the threat environment. Instead, the proliferation pathway is heavily

moderated by domestic institutional factors. A state's civil-military relations, and the independence of its nuclear bureaucracy, affect the likelihood that the government will decide to push a program forward. More militarized governments are less likely to accelerate a nuclear weapons program, while states with more independent nuclear agencies are more likely to make an acceleration decision.

I test these theories with statistical models, using original data. I then use case studies to illustrate the various mechanisms that underlie the theories.

Nuclear Weapons Programs and Decision Making

A government must have both the necessary motivation and opportunity to decide to start a nuclear weapons program. The leadership must have the political will needed to make the decision to embark upon a course of action that is costly, will require an unknown period of years to produce the desired outcome, and will alter the identity of the state. And the state must also have the capacity to develop or obtain the needed technology, fissile material (nuclear fuel), and expertise. States that have the capability to develop nuclear weapons, but lack the motivation to do so, will not start down the path to a nuclear arsenal.

Once a government has made the decision to start a nuclear weapons program, how that program is executed depends on subsequent decisions. The state may change the pace of the program by deciding to accelerate or decelerate nuclear weapons development. Pace decisions have never been systematically analyzed across cases. In this dissertation, I identify acceleration decisions in every nuclear weapons program and determine what conditions put a state at greater or lesser risk of making a decision to accelerate.

The pace of the program is a different concept than that of the stage a program is in. A decision to accelerate a nuclear weapons program is, at the time it is made, unobservable. These decisions are typically made in secret by a limited number of people, and are not revealed to those outside either the nuclear program or the related government agencies. A government that decides to accelerate a program – perhaps by deciding to initiate a crash program to acquire a bomb in a short time frame, or to increase the rate of weapons production – will have to wait months or years for the program to achieve the desired outcome of the acceleration. That outcome – say, a testable nuclear weapon – will be the observable result of the decision.

The stage of a program is measured by the level of nuclear weapons development the state has attained. The most simple measure of stage would be to assign a program in a given year to one of three ascending categories: whether the program has acquired fissile material (uranium or plutonium), whether the program has weaponized that material (i.e. constructed a nuclear bomb), and whether the state has the ability to deliver a bomb to a target. In reality, the path of development is much more complex.

There are many milestones along the path to developing nuclear weapons. States establish a research and development program, obtain fissile material, build a nuclear reactor, operate the reactor, enrich fissile material so it can be used in a bomb, test a bomb, and develop delivery systems. However, it is not always obvious when a state moves from one milestone to the next, in part because these accomplishments are often closely guarded secrets. Further, the progression along the path of nuclear weapons development is not always linear. States may skip over some milestones, perhaps accumulating a stockpile of nuclear weapons and developing delivery systems before it tests a prototype bomb.

Consider the case of Pakistan, which started its nuclear weapons program in 1972. A decision to start a militarized nuclear program occurred after a civilian nuclear program had been in place for nearly a decade. Two decisions to accelerate the program were made in the 1970s, but it would not be until 1983 that Pakistan reached the milestone of producing weapons-grade uranium. The two unobservable decisions affected the program, but the desired outcomes were not realized until years afterward.

Table 1.1 Pakistani Nuclear Weapons Program by Pace and Stage

Year	Type: Pace or Stage	Event
(1965)		(Nuclear reactor goes critical)[1]
1972		Decision to start nuclear weapons program[2]
1975	**Pace**	**Decision to speed up the program[3]**
1977	**Pace**	**Decision to speed up the program[4]**
1983	Stage	Produces highly enriched uranium[5]
	Stage	"Cold" test of nuclear device[6] [7]
1986	Stage	Nuclear weapons deliverable by plane[8]
1989	Stage	Nuclear weapons assumed to be deliverable by missile[9]
1989	**Pace**	**Decision to slow down the program[10]**
1998	Stage	Plutonium production[11]
	Stage	Fission tests[12]
2007	**Pace**	**Decision to speed up the program[13]**

[1] Chakma 2008, 13.
[2] Spector 1990, Kapur 1987, Khan 2013.
[3] Perkovich 1999, 194.
[4] Kapur 1987, 103.
[5] Reported by A. Q. Khan in *The News* (Islamabad) on 30 May 1998, this date is widely accepted. The first enrichment of uranium at low levels occurred in 1978.
[6] Khan 2013, 185.
[7] A cold test is a nuclear weapons test that, instead of using weapons grade uranium or plutonium, uses a non-weapons-grade material (such as depleted uranium) at the core.
[8] McDonnell 2013.
[9] Spector 1990, 103.
[10] Spector 1990, 104-105; Cheema 2010, 199.
[11] Albright and Brannan 2011.
[12] Cheema 2010, 200.
[13] Thom Shanker and David Sanger reported in a New York Times on 17 May 2009 ("Pakistan is Rapidly Adding Nuclear Arms, U.S. Says") evidence of acceleration. The Institute for Science and International Security, among others, reported in May 2009 that Pakistan was near completion of two new plutonium-producing reactors at its Khushab facility. Indications are that the decision to accelerate was made two to three years earlier. The Pakistan News Service reported on 18 August 2007 that, according to military

Given the series of milestones listed on the previous page, the Pakistani timeline appears to skip over some, and even returns to one later. For example, delivery systems were developed *before* the nuclear weapons to be delivered were fully tested. Fission tests were not conducted until more than ten years after the bombs were able to be brought to their targets. Pakistan did not follow a linear progression of steps toward nuclear weapons.

Pakistan did not progress steadily toward nuclear weapons, either. In the 1970s, Pakistan accelerated its program twice. It slowed its pace in 1989 when both civilian and military leaders agreed that Pakistan had a sufficient nuclear capability at that point to credibly deter foreign aggressors, and possibly also to provide reassurance to the United States, which was applying diplomatic pressure to Pakistan to stop their nuclear weapons program.[14] Most recently, in 2007, Pakistan decided to accelerate its program by expanding its plutonium production, and built new facilities for that purpose.

The Difference Between Nuclear Pace and Nuclear Posture

The results of the 2007 Pakistan acceleration were not observed by American newspapers until 2009. Intelligence services are sometimes able to observe effects earlier, but not always; in this case, satellite imagery revealed the increased pace of work on facilities, but the observations were made well after the decision had been made. Decisions about the pace of a nuclear weapons program are usually not immediately observable.

A nuclear weapons program consists of the research and development of weaponry and weapons systems, and of the production of fissile material and the weapons

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sources, President Musharraf had issued directives to accelerate its program, including accelerating work that was already underway on a heavy water reactor at Khushab.

[14] Cheema 2010, 199; Spector 104-105.

themselves. Nuclear weapons programs may not even result in the acquisition of nuclear weapons. But if a state acquires nuclear weapons, military and civilian leaders may discuss whether and how the weapons should be deployed, and in what circumstances they may be used. Tactical decisions regarding deployment, and strategic decisions regarding nuclear doctrine, are decisions about the *use* of the weapons, not the *development* or *production* of the weapons.

When the driver of a two-seater sports car decides to make a turn, the car will complete the turn in almost the same moment the driver turns the wheel. But when the driver of a semi truck decides to make a turn, the entire body of the truck will not complete the turn for several seconds, long after the driver has turned the wheel. A nuclear weapons program is much more like the semi truck then like the sports car: massive, slow to respond, and with results that require patience to realize.

A nuclear *posture* decision is more like the sports car. Nuclear posture is the term for the way a state arranges its existing nuclear weapons that have been produced by the nuclear weapons program. The way the weapons are managed, the number and types of weapons the state possesses, and the way the state has arranged those weapons for possible use, are part of the state's nuclear posture. If a state feels threatened, it can respond to the threat quickly by changing its nuclear posture. For example, a state could make a decision to fuel its nuclear bombers and place pilots on stand-by, and that decision could be executed, and potentially observed, within a matter of hours.

Responding to a threat by making a decision to accelerate a nuclear weapons *program*, on the other hand, would not bring about immediate, useful results. These decisions may incur very high costs and are implemented within bureaucratic structures

that require time to adapt. A program decision may require building of new facilities, hiring new personnel, expanding a partnership with a foreign government, or finding new sources of material or equipment. Deciding to increase work on an existing project to move up the timeline, for example, or to expand the program from uranium bombs to plutonium bombs as well, would be long-term, highly secret initiatives that would take months or years to come to fruition.

The Role of the Executive

The two kinds of decisions I analyze in this dissertation are program start decisions and program pace decisions. How are these decisions made? Who has the authority to make a decision to start a nuclear weapons program? And who makes pace decisions once a nuclear weapons program is underway?

The decision to start a nuclear weapons program is a political one, ultimately made by the head of state. In most cases, the head of state has made the decision along with a small number of close advisors. Subsequent decisions regarding the pace of the ongoing program typically also require authorization by the head of state. Because power is concentrated in the executive, decision making is often attributed to the personal traits of individual leaders. When a "strong" president is observed advancing his nuclear weapons program, or a "hawkish" prime minister decides to expand the production of fissile material, the assumption may be made that nuclear policy making depends on personality and leadership style.

However, leaders do not make decisions in a vacuum. Domestic actors, like the military, the nuclear agency, or a legislature that controls the purse strings, may influence

the head of state. International actors, such as a state's rivals, or benefactors who impose pressure on the state to cease nuclear development, may also exert influence on the executive. Attributing decision making to the personal characteristics unique to each leader is not only theoretically unsatisfying, it also ignores the institutional structures and external environment that shape a leader's perceptions and beliefs.

In order to make a decision, the head of state must obtain information and develop a set of possible policy options from which to choose. State organizations and agencies have opportunities to shape the head of state's understanding of the strategic environment, the utility of nuclear weapons, the financial cost to the state, the potential effect on the state's international reputation, and a multitude of other factors that affect decision making. Military leadership may have a different viewpoint than scientific leadership. A group that has greater influence over the executive has greater opportunity to inform and persuade.

Sometimes, a nuclear weapons program decision is made when a new president or prime minister comes to power. Some heads of state have strong favorable or unfavorable attitudes regarding nuclear weapons, and may seize the opportunity to change state policy upon taking office. But although a change in leadership has at times preceded a start decision or pace decision, it is not a common or widespread causal factor leading to either type of decision. Cases in which a head of state had a strong personal stake in the nuclear weapons program are particularly interesting and thus well known, but it is more typical for the executive to rely upon advisors, agencies, and other organizations to suggest a set of policy choices and then to advocate for their preferred policies within that set. Indeed, even those executives who had exceptionally high levels of personal involvement in nuclear affairs still did not operate alone.

Because leaders are influenced by their political and global environments, and by the people and institutions they interact with, we can find patterns in the circumstances that affect whether a decision is made to start a nuclear weapons program, and in what happens afterward. Even though individual heads of state are unique, and have unique personalities, life histories, and leadership styles, there are common situations and conditions that tend to make leaders more or less likely to make certain kinds of nuclear weapons program decisions.

Modeling Decision Making

In this dissertation, I develop theories of decision making specific to each of two types of nuclear program decisions: start decisions and pace decisions. I use statistical models and case studies to test these theories. First, I use event history models to test whether certain factors are likely to increase the risk of start decisions, and which factors are likely to increase the risk of pace decisions. I find that the circumstances that affect the risk of a decision to start are different from those that affect the risk of a decision to accelerate. Later, I explore these dynamics in three case studies: Pakistan, Brazil, and the United States.

Because a decision to start or accelerate a nuclear weapons program does not immediately produce visible results, and because the physical outcome is easier to see than the decision, knowledge of the decision usually comes only afterward. Determining when the decision was made can be difficult, as these decisions are often made in secret. Likewise, determining the precise causal influences that underlie decision making is a

difficult task. Hans Born, Bates Gill, and Heiner Hänggi write:

> "Despite its importance, domestic nuclear weapon governance is sparsely researched. This is largely because research in this highly sensitive policy area is hampered by secrecy in all possessor states . . ."[15]

Because of this difficulty, there is disagreement over the precise dates of some of the more secretive start and pace decisions. In some cases, the date of the decision was documented directly or by key witnesses. But in others, the formal decision is less clear.

Through extensive case research, including both government documents and secondary sources, and using new information that has become available only within the last few years, I have developed an updated list of all decisions to start nuclear weapons programs. This list of countries and dates improves upon previous work.[16] I do not rely on public statements made by governments, as a state may claim to adhere to nuclear non-proliferation ideals when it is actually pursuing a clandestine nuclear weapons program.[17]

Using an event history model, I identify the conditions under which states are put at higher or lower risk of starting a nuclear weapons program. This type of statistical model is used to estimate the risk of some event occurring. In this model, the event in question is the decision to start.

A comprehensive list of pace decisions has never before been compiled. I used primary source documents when possible, along with secondary sources, to identify pace decisions for each of the twenty-seven states that have started a nuclear weapons program

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[15] Born et al 2010, 4.
[16] A table comparing the countries and dates I have identified with those that other scholars have identified appears in Appendix 1.
[17] There are several instances of governments misleading domestic and international audiences in this way. One example is Pakistan's proposal for a South Asian nuclear weapons free zone in November 1972, just months after having made the decision to pursue a nuclear weapons program.

or possessed nuclear weapons.[18] To qualify as a pace decision, a decision had to be made to accelerate or decelerate a nuclear weapons program, and thus, posture decisions are not included.[19] I was able to find information about every state, even in instances where thorough case histories have not yet been written.

Using this new data set of decisions, I once again employ an event history model. In this case, the decision to accelerate a nuclear weapons program is the event in question. I analyze the conditions under which governments are at greater or lesser risk of making acceleration decisions.

Statistical modeling and case studies provide empirical support for the theories I outline below. One could argue that certain decisions seem to have been brought about by very specific causes, or that each decision may be situated in a unique historical and cultural context. I do not claim that the theories I propose explain every nuclear weapons program decision. While it is true that some decisions may be exceptional, developing a theory of decision making is an exercise in seeking out common factors that systematically affect the likelihood of a decision being made.

Structure of the Dissertation

Why States Start Nuclear Weapons Programs

In order for a state to decide to start a nuclear weapons program, two conditions are required: motivation and opportunity. The leadership must have political will to make the

[18] Ukraine, Belarus, and Kazakhstan inherited their nuclear weapons in the aftermath of the collapse of the Soviet Union. Upon becoming independent states, each of the three governments had to decide how to manage the Soviet nuclear weapons and facilities left on their soil that they now suddenly possessed.
[19] The full list appears in Appendix 2.

decision, and the belief that the state has, or will be able to build, the capacity to develop and produce nuclear weapons.

State capacity to pursue a nuclear weapon program is comprised of wealth, energy, materials, and knowledge. Many states have the capability needed to pursue nuclear weapons, but choose not to. A state must also be willing to proceed down the costly and controversial path to the bomb. Three key categories of motivators may drive states to start a nuclear weapons program: Security, domestic political interests, and norms.[20] As the case histories of nuclear weapons-seeking states indicate that each of these motivators has led various states to make the decision to start a program, recent scholarship has used quantitative methods to systematically analyze which motivators affect decision making.[21] In Chapter 2, I explain which of these conditions affect a state's risk of making a decision to start a nuclear weapons program.

Program Pace and Civil-Military Relations

Once a nuclear weapons program has been initiated, the path that program takes is dotted with decisions regarding how to proceed. With some exceptions, security concerns are no longer the primary motivator for how to conduct a program. Instead, domestic institutional characteristics determine the likelihood of program expansion.

The literature has offered no theory of civil-military relations and the pace of nuclear weapons programs. Strong or weak civilian control of the military has been studied with regard to command and control systems, the delegation of authority to use nuclear

[20] Sagan 1996.
[21] See in particular Singh and Way 2004, Jo and Gartzke 2007, Fuhrmann 2009, Kroenig 2009, and Bleek 2013.

weapons, and the security and potential for accidental launch of nuclear weapons.[22] But there has been no systematic examination of civilian control of the military with regard to a program's path.

In Chapter 3, I argue that states with weaker civilian control of the military make different pace decisions than states with stronger civilian control do. The more militarized the government is, the lower the risk that the government will decide to accelerate a nuclear weapons program. I propose six reasons why this is true: Militaries have traditional interests, work to build arsenals, are inwardly focused, strive to minimize civilian interference in military affairs, desire prestige, and believe that nuclear weapons are unusable. In general, militaries are more likely to pursue their own organizational interests rather than the interests of the state as a whole.

Program Pace and Agency Independence and Origin

The nuclear bureaucracy manages and operates a nuclear weapons program, and provides information on the program to state decision makers. Despite the importance of the nuclear agency, no theory of bureaucratic power and nuclear weapons programs has previously been developed. As there had been no "compelling measures of bureaucratic power and autonomy," quantitative analysis of the characteristics of nuclear agencies had never been done.[23] In Chapter 4, I propose a theory of nuclear bureaucratic influence on the executive. Using original measures of bureaucratic power and autonomy, I demonstrate the effects of agency independence and agency origin on the risk of a state choosing to accelerate its nuclear weapons program.

[22] See Feaver 1993 and Sagan 1996.
[23] Sagan 2011.

Nuclear weapons programs are highly secret, extremely technical, and cloaked in the mysticism of their extraordinary destructive power, limiting the understanding of program outsiders. The dearth of comprehensible information available to decision makers heightens the power of the experts within the nuclear bureaucracy. Domestic nuclear agencies with a high level of independence will be able to influence policy making to a greater degree than domestic nuclear agencies with less independence, because heads of state select from policy options provided to them from below. The more independent a nuclear agency is, the more likely it is to be able to influence decision makers to adopt its preferences. The key characteristics determining high influence include having the ear of the head of state, having independence from the cabinet or other executive bureaucratic apparatus, experiencing limited state oversight, and receiving legal codification of some or all of these institutional features.

Case Studies

In Chapter 5, I examine nuclear weapons program decisions in three countries: Pakistan, Brazil, and the United States. Statistical modeling allowed me to test broad theories of state decision making behavior by analyzing all states that have ever sought nuclear weapons, or for start decisions, by analyzing all states in existence during the time period in question. Case studies provide the benefit of adding context and depth to broad theorizing. In each of the three cases, I show how domestic institutional factors and the external security environment played a part – or didn't – in key nuclear weapons program decisions and over the life of the program.

I conclude the dissertation in Chapter 6 with a review of the key findings, a discussion of the implications of this research, and a look ahead at future research.

CHAPTER 2

Why States Start Nuclear Weapons Programs

Why do only some states with the capacity to pursue nuclear weapons actually embark upon a weapons program? Is the decision driven by the desire for the kind of international status that comes with membership in the "nuclear club"? Do domestic political interests lead a state to pursue nuclear weapons? Or do a state's security concerns ultimately provoke the decision to start a program?

The decision to start a nuclear weapons program is a political one. Typically, the head of state authorizes a militarized nuclear program that utilizes nuclear technology to produce fissile material and develop bombs. Rarely, the decision to start a program has amounted to an order to purchase an "off the shelf" capability from other states or on the black market. That approach has not yet proven successful for any state that has attempted it.[1] Regardless of the details involved in the scale or type of the nuclear weapons program, it is the executive who ultimately has made the decision to weaponize.

Past personal experiences, and individual personality and characteristics, shape the head of state's worldview. Some presidents or prime ministers are more hawkish and inclined toward aggression; others favor diplomacy and the pursuit of peace over

[1] Libya and Australia both initially showed interest in simply purchasing nuclear weapon. Neither effort was successful. Australia ended their pursuit of nuclear weapons, and Libya turned toward purchasing the technology and materials needed to construct their own production facility.

militarized action. But the executive does not make decisions in a vacuum – not even the often secret and more isolated decision to pursue nuclear weapons. He or she may be influenced by many different people, institutions, and ideas. The head of state might be concerned about the rise of a rival state, or could be thinking strategically about potential future conflicts. Some leaders hold lengthy debates in parliament, or with cabinet members or smaller groups of advisors. Historians have detailed the trusted friendships that have existed between some of these heads of state and the men they have named to head their nuclear programs.[1]

Because leaders are influenced by their political and global environments, and by the people and institutions they interact with, we can find patterns in the circumstances that affect whether a decision is made to start a nuclear weapons program. Even though individual heads of state are unique, and have unique personalities, life histories, and leadership styles, there are common situations and conditions that tend to make leaders more or less likely to make this kind of decision.

These conditions can be categorized in terms of motivation and opportunity. Both must be present for the decision to be made. The state must have the capacity to develop or purchase a nuclear weapons program, or at least must hold the belief that it will soon be able to develop the necessary capacity. And there must exist political will to start down the path to nuclear weapons. Not all states that have the capacity to start a program will do so, because not all capable states also possess the motivation to proceed.

[1] A scientist's intent to develop weapons, while potentially influential, is not a political decision. Although some nuclear scientists have had a great deal of freedom to pursue their own agendas, it is the political leadership of a country that has the authority to decide to develop nuclear weapons.

Capacity

In order to develop a nuclear weapons program, a state needs wealth, energy, materials, and knowledge. The thresholds for the knowledge and funding needed to design a single working nuclear weapon are relatively low. A state's capacity for starting a nuclear weapons program is centered not in the finished weapon, but in the building and operation of the facilities and technologies needed to produce fissile material and, later, delivery systems for the weapons.

Because of this, nuclear weapons programs are extraordinarily expensive. Producing the fissile material needed for atomic bombs is one of the highest-cost elements of a nuclear weapons program. International restrictions on the production and trade of fissile material have made it difficult to obtain the components needed to build a bomb. Whether a state decides to produce uranium or plutonium weapons – and in many cases, both options are explored – the cost of enriching or processing the material is enormous. Consider the Manhattan Project: approximately 80% of the total funding for the Manhattan Project was allocated to Oak Ridge, the "secret city" established in Tennessee that produced the fissile material for the U.S. nuclear weapons effort.[2] In 2014 dollars, that totals more than $16 billion. Even with advances in uranium enrichment and plutonium reprocessing technology, the cost of producing weapon-useable uranium or plutonium still dominates a nuclear program's budget.

Operating one of these facilities requires an enormous amount of electricity. Whether a state is operating nuclear reactors and reprocessing plants to produce plutonium, or is using gaseous diffusion or centrifuge cascades to enrich uranium, it takes a

[2] Schwartz 1998.

great deal of energy to operate the plants that produce fissile materials. A state must have enough electricity to do this.

A state can develop its own plants, facilities, and reactors. Alternatively, it can buy them from other states and companies, or it can obtain assistance and build them together with another state. While a state doesn't have to have the ability to build all of this infrastructure itself, it does has to at least have enough money to purchase those technologies, and the international restrictions on doing so have continued to grow over the last five decades. Furthermore, the nonproliferation regime has evolved over time to more effectively prevent the spread of the kind of technology deemed "dual use," or useable for both civilian and military purposes.[3] If a government desires a nuclear reactor or reprocessing plant to produce weapons-grade material, the best way to ensure success is to build covert indigenous facilities in order to avoid scrutiny by international inspectors.[4]

Knowledge is the last component. It is certainly true that less knowledgeable programs may proceed more slowly and suffer more setbacks and breakdowns, and that their weaponry will, at least at first, be less sophisticated. But states with less experience in nuclear science and engineering have historically sent their scientists abroad to learn, or have established partnerships with foreign institutes and universities that allow their nuclear experts to visit the less experienced country in order to educate those scientists. Overall, a relative lack of scientific knowledge regarding nuclear weapons will not be much of a hindrance when leaders weigh the decision to start a program.

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[3] Montgomery 2013.

[4] A few examples: North Korea did this for more than a decade before withdrawing from the NPT in 2003. See Hecker 2010. Syria built a covert nuclear reactor with North Korean assistance. See Pollack 2010. Taiwan began building small-scale secret facilities for plutonium extraction. See Spector 1990. Argentina began secretly constructing a uranium enrichment facility to avoid IAEA safeguards. See Reiss 1995. Brazil built a secret nuclear reactor designed to produce plutonium. See Reiss 1995.

It is important to note that states develop even indigenous nuclear programs with a great deal of assistance from other nuclear powers. In building nuclear programs, states have always received material and scientific aid from other governments, and from corporations, which are sometimes private but most often enjoy state support. No state has pursued a nuclear program entirely alone, and thus no state has to possess the complete capacity to develop such a program without assistance.[5]

Motivation

Many states have the capability needed to pursue nuclear weapons, but choose not to. A state must also be willing to proceed down the costly and controversial path to the bomb. Sagan's 1996 article "Three Models in Search of a Bomb" identifies three different theoretical motivators that may drive states to start a nuclear weapons program: Security, domestic political interests, and norms. As the case histories of nuclear weapons-seeking states indicate that each of these motivators has led various states to make the decision to start a program, using quantitative methods to systematically analyze the conditions under which states make these decisions can help determine what motivators are the most important.

Security

States may be motivated by national security factors to begin a nuclear weapons program. The logic of balancing – the idea that a state in an anarchic international system

[5] The vast majority of nuclear assistance provided by one state to another is civilian assistance, which may consist of transfers of technology, material, or knowledge. In a few cases, states have received sensitive nuclear assistance, which is assistance in the design and construction of nuclear weapons, the transfer of weapons-grade fissile material, or assistance in building facilities that can produce weapons-grade fissile material. For more on this topic, see Fuhrmann 2009 and Kroenig 2009.

will seek not to maximize power, but to balance against a stronger power – has led scholars to theorize that a state facing an opponent possessing a stronger conventional threat may seek to change the asymmetry of power by pursuing nuclear weapons.[6] A state with nuclear rivals may decide to proliferate to even the playing field[7]; Sagan (1996) offers the term "strategic chain reaction," where each state that develops nuclear weapons inspires other states to proliferate to fend off the new threat of nuclear attack. Alternatively, a rival of a nuclear state may shy away from proliferation out of fear of sparking an arms race.[8]

Not all security concerns are equal. An emerging threat from a regional rival may motivate a state to make policy decisions that would not be considered if a military buildup were observed in an ally, or in a relatively weak neighbor. Most recent scholarship on the threat environment has attempted to separate out which elements of the security environment may prompt states to decide to pursue nuclear weapons. Among these elements are measures of the intensity of the security threat, usually calculated based on the militarized disputes a state is involved in, and whether a state is part of a long-term rivalry.[9] Whether a threat emerges from a nuclear power or non-nuclear power should also matter to a state thinking about whether to start its own nuclear program.

Security guarantees from powerful allies may mitigate a state's security concerns. Until the collapse of the Soviet Union in 1991, the post-World War II nuclear weapons era coincided with the Cold War, a period dominated by the "superpowers" of the United States and Soviet Union. Many states aligned militarily with one of the two patron states, whether for protection, for assistance in improving the smaller state's military and weaponry, or

[6] Potter 1982, Kapur 2001, Quester 1973, 2005.
[7] Foran and Spector 1997.
[8] Bueno de Mesquita and Riker 1982, Mandelbaum 1995.
[9] Singh and Way 2004, Jo and Gartzke 2007, Kroenig 2009, Fuhrmann 2009, Bleek 2013.

both. Most relevant to the question of why states choose to start nuclear weapons programs is the presence or absence of a security guarantee from the United States or Russia. If either nuclear weapons power maintains a formal defense pact with a protégé, that protection may obviate the need for the protected state to acquire its own nuclear weapons.

Domestic Institutions

Domestic institutions may dampen or heighten a state's motivation to pursue a nuclear program. Similar types of governments, which share certain institutional characteristics, may respond to the question of nuclear weapons in similar ways.

The distribution of power and authority between a country's military and civilian institutions can impact national security policy making. Do civil-military relations affect a governmental decision to begin or forgo a nuclear weapons program? Militarized governments – those in which civilians have weaker control of the military – may be more likely to choose to pursue nuclear weapons. There are many reasons why this may be so. For example, possessing nuclear weapons allows a military to wield tremendous destructive power that could deter potential enemies. A nuclear arsenal that serves as a credible deterrent could free the military to pursue expansionist goals conventionally, believing that no adversary will dare respond to an attack.[10] And militaries may desire the prestige that nuclear weapons confer. If the military's influence on policy making is

[10] See Chapter 5 for a discussion of how Pakistan's military seems to have used just this logic in deciding to enter Kargil in 1999.

relatively strong, a state may be more likely to pursue military interests and thus more likely to make the decision to add nuclear weapons to its arsenal.[11]

More democratic governments may be more responsive to public opinion and may shy away from nuclear weapons when the population opposes them. Autocracies may be more likely to embrace nuclear weapons programs because the concerns of their citizens cannot be expressed in free elections.[12] Public opinion opposing nuclear weapons seems to have been salient enough to Swedish politicians for Sweden to scuttle their plans to study and ultimately even develop military uses for nuclear power; in other countries, public opposition has not been large enough or important enough to be decisive.[13] As there is currently no universal measure of public feeling regarding nuclear weapons across countries, this dynamic cannot be directly tested.

It is also possible that democratic regimes would be more likely to use a national nuclear program to appease nationalist populations.[14] Nuclear weapons are symbolic of national strength, ability, and power: qualities that demonstrate superiority. Perkovich (1999) argues that India's democratic regime saw the nuclear program as a way to appeal to and manage nationalist sentiment. Yet states that fall on the more autocratic end of the spectrum of regime type may also have an interest in using nuclear weapons that stems from nationalism – an autocratic government might use a nuclear program either to quiet nationalist forces or to whip up nationalist sentiment to further bolster the regime.

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[11] This is only a very brief outline of how civil-military relations may impact the *initial* decision to start a nuclear weapons program. See Chapter 3 for a discussion of military interests/priorities and whether militaries are more or less aggressive than civilian governments.
[12] Chubim 1994.
[13] Jonter 2010, Cole 1997. The Swedish electorate was generally in favor of nuclear pursuits in the early and mid-1950s, as did the Prime Minister at the time and leading Social Democrats; public sentiment changed to opposition in the early 1960s.
[14] Perkovich 1999, Snyder 2000.

Perkovich also points out two other characteristics that India held because of its democratic character that could have *lowered* the chances that India would pursue nuclear weapons, or at least slowed India's progress. Nuclear weapons, some of the elite believed, were at odds with India's history: nonviolence had been a key factor in achieving India's hard-won independence. In addition, India, as a democracy, could not devote resources to a nuclear program at the expense of the well-being of its citizenry.[15] Democracies may be more hesitant to embark upon the costly path to nuclear weapons, knowing that the sacrifices necessary will not be tolerated by the electorate.

As measured by regime type, then, similar domestic institutions are unlikely to have a common influence on the decision to start a nuclear weapons program. The kinds of domestic institutions that are more likely to impact that decision in predictable ways are difficult to measure. We know that the personal relationships between heads of state and scientists matter, but friendships cannot be quantified, compared, and assessed across a population of cases. The power of the nuclear bureaucracy should influence the head of state in cases where a civilian nuclear program preceded a military nuclear program, but many nuclear bureacracies did not develop until after the decision to start a nuclear program had already been made. Domestic coalitions and interests, either pro- or anti-nuclear, shape the political environment in which a head of state must decide whether to pursue nuclear weapons. Measuring those coalitions and their import would be a fascinating but enormous undertaking. Without the ability to measure those components of the domestic environment, a quantitative analysis of the domestic institutional factors

[15] Perkovich 1999, 47.

affecting a government's decision to pursue nuclear weapons is incomplete. Further research is needed to address those topics more fully.

Prestige

The cachet of nuclear weapons has changed over time. The "nuclear club" – and the very phrase *nuclear club* itself indicates that nuclear weapons confer exclusive status upon those who possess them – was prestigious in the mid-twentieth century because only an advanced society could master the physics, chemistry, metallurgy, and industrial science necessary to become a nuclear power. The awesome and terrible destructive power of nuclear weapons, and the catastrophic consequences of nuclear accidents, were not as widely understood as they would come to be years later. Now, those wishing to join this club are most often branded as rogues; irresponsible states willing to risk great harm at the expense of national ambition.[16] As the international nonproliferation regime has grown in size and scope, the pursuit of nuclear weaponry has experienced a decline in legitimacy.[17]

Yet nuclear weapons remain a "normative symbol of modernity."[18] As a symbol, they invoke technological ability, national achievement, military might. All five permament members of the Security Council are nuclear weapons states. Of the Group of Eight (G8), four possess nuclear weapons, and the rest are civilian nuclear powers. France sought nuclear weapons, in part, to restore pride in France and return the country to a place of global power after the country's embarrassing loss at Dien Bien Phu in 1954.[19] China likely

[16] Sagan 1996.
[17] There is a broad literature on the issue of who determines when nuclear weapons are legitimate and when they are not. Nuclear racism, nuclear orientalism, and nuclear apartheid are terms that refer to the viewpoint that a double standard exists in the nonproliferation regime when states aver that only the original nuclear powers have a right to possess nuclear weapons. See Hugh Gusterton, "Nuclear Weapons and the Other in the Western Imagination," *Cultural Anthropology* 14(1), Feb. 1999, for an introduction to this subject.
[18] Singh and Way 2004.
[19] Norris et al 1994.

had prestige in mind along with security when it sought an end to "nuclear bullying" by beginning its own program.[20] Countries like Libya, Brazil, or South Africa, which faced only limited security threats at the time of the decision to start a program, may primarily have hoped to attain greater global status through their endeavors.

A Statistical Model of Decision Making

Which of these factors are the most relevant to the questions of why and when the political decision is made to start a nuclear weapons program? Statistical models can help identify the most likely causes of a decision. Models that allow us to account for the amount of time that elapses before a decision is made can also help us think about the timing of these decisions. In order to analyze the conditions under which states are at risk of starting a nuclear weapons program, we must examine these conditions across time and space. I begin this analysis from 1939, when scientists were first beginning to make discoveries about nuclear fission, and I include every country in the world.[21]

Event history models, also known as survival models and as duration models, allow the researcher to examine the risk that some event will occur. Here, the event in question is the political decision to start a nuclear weapons program. There are two groups of states: those that make the decision to start, and those that do not. At the outset, which group a given state belongs to is unknown. By using an event history model, I can identify the variables that best predict which states will start programs.

[20] Feigenbaum 2003.
[21] Otto Han, Lise Meitner, and Fritz Strassmann first split the atom in 1938. Following this discovery, 1939 is generally considered to be the year when nuclear physicists began, as a community, to dedicate great effort to studying nuclear fission.

In any given calendar year, a country is at risk of making the transition from not pursuing nuclear weapons, which is stage 1, to pursuing nuclear weapons, which is stage 2. Event history analysis models both the length of time spent in stage 1 and the decision to move to stage 2. As there is no reason to expect stage 1 duration times to follow any particular distributional form, I use a Cox proportional hazards model for this analysis. Further details regarding the model can be found in Appendices 3-5.[22]

The Decision to Start a Program

Making the decision to start a nuclear weapons program is a political action. Based on evidence that includes declassified government documents, interviews, and expert knowledge, we can presume that a state's decision to pursue nuclear weapons is made by that state's political leadership. The head of state ultimately decides whether or not to start down the proliferation pathway. Political decisions are analyzed in the models presented here. Although there are several cases in which a scientist or group of scientists intend to use a nuclear program to develop weapons, the plans of nuclear scientists are not political decisions. For example, Dr. Homi Bhabha, the father of the Indian nuclear program, aimed to steer India's program toward weaponization long before the political decision was made by Prime Minister Jawaharlal Nehru in 1964. This distinction is illustrated by the conversation a U.S. Major General observed Nehru hold with Bhabha: Nehru asked Bhabha if he could develop a nuclear bomb, and Bhabha answered that he could, given time. Nehru then directed Bhabha not to proceed until Nehru gave him permission.[23]

[22] I am indebeted to Robert Franzese, James Morrow, Janet Box-Steffensmeier, and Benjamin Jones for their insights into, and advice on, event history modeling.
[23] In Perkovich 1999, 36.

Table 2.1 Decision to start nuclear weapons program

Country	Year of decision
Argentina	1976
Australia	1945
Brazil	1979
China	1955
France	1954
Germany	1941
India	1964
Iran	1974
Iraq	1971
Israel	1956
Japan	1941
Libya	1969
North Korea	1968
Pakistan	1972
Russia	1943
South Africa	1974
South Korea	1971
Sweden	1952
Switzerland	1946
Syria	1979
Taiwan	1967
United Kingdom	1941
United States	1942
Yugoslavia	1947

There is some disagreement over the precise dates of some of these decisions, as they were made in secret. In some cases, documentation or agreement among key witnesses makes the date of the decision clear. In others, we can observe the start of a program – for instance, when the Argentine military regime replaced the civilian head of Argentina's nuclear program with a military official – but must deduce when the formal decision to start was made. Through extensive case research, including both primary and secondary sources, and using new information that more recently became available, I have compiled a list of countries and dates that is more accurate than the various countries and

dates proposed by other scholars. That list appears above; a table comparing the lists of dates is available in Appendix 1. In most versions of the model, the key results stand up to the older specifications of the dependent variable as well.

Model Specification

The event history model I construct allows me to identify which variables put states at higher or lower risk of starting a nuclear weapons program. The variables included in the model are measures of the "capacity" and "motivation" factors discussed above.

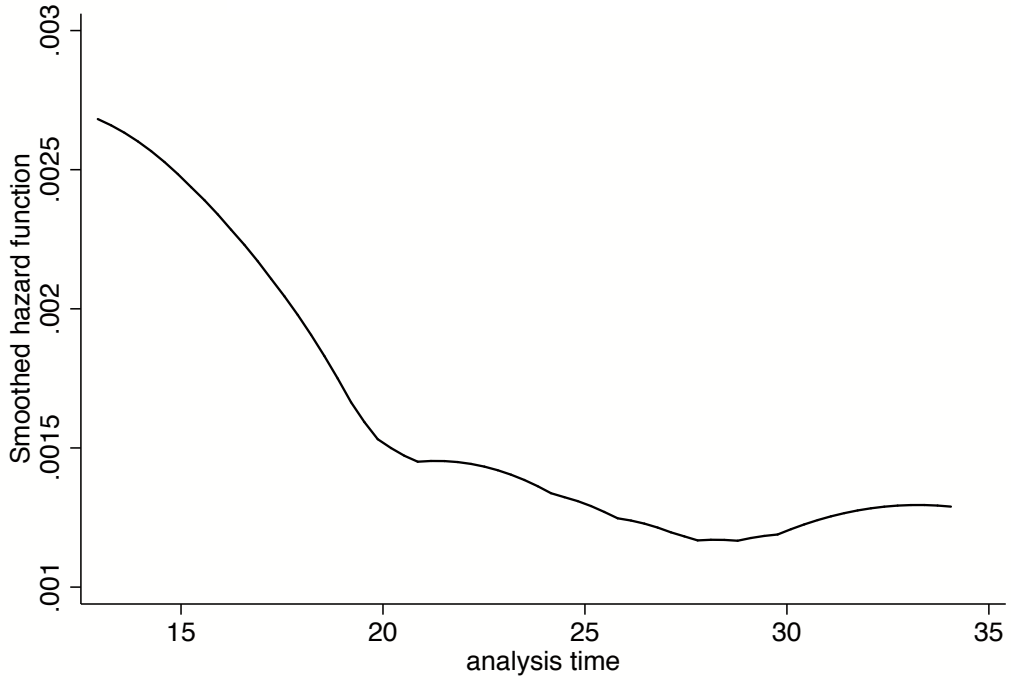
The capacity variables are wealth, civilian nuclear experience, and nuclear civilian assistance. The motivation variables are divided into three subcategories. The first, domestic institutional factors, contains two variables: civil-military relations and regime type. The second, security factors, contains five variables: disputes, strategic rivalry, nuclear strategic rivalry, threat level, and defense pacts. The last, prestige, contains a variable indicating whether a state has ratified the Nuclear Non-Proliferation Treaty. Each of these variables will be discussed in the results section below.

When are States Most at Risk of Starting a Program?

Estimating an event history model allows us to calculate a hazard rate. The hazard rate, also called the hazard function, measures the likelihood of a transition from stage 1 (no pursuit of nuclear weapons) to stage 2 (pursuit of nuclear weapons) at a given time. In this model, the hazard rate gives us the probability that a state will decide to start a program at each time in the state's history from 1939 (or from the start of the creation of the state, if the state achieved independence after 1939), and that decision to start is

conditional on a state being in stage 1 up to that point.[24] This means that at a selected time, given that a state has not yet made the decision to pursue, we can determine how probable it is that the state will now make a decision to pursue. The hazard rate thus accounts for the history of the state when calculating the risk of transitioning from stage 1 to stage 2.[25]

Figure 2.1 Hazard rate of decision to start nuclear weapons program



The risk of starting a program is highest during the first twenty years, but that risk drops quickly during that time period. In fact, the risk of pursuing nuclear weapons drops by more than two-thirds. After the twenty-year mark, the hazard rate flattens briefly and then descends more slowly, indicating that the risk of starting a program levels off and then

[24] It is possible that states created in the year 1939 or later may be different from previously established states. The changing state of the world may introduce time-dependent factors that influence the decision to go nuclear. One way to test for this is to include a categorical variable that identifies all states that formed post-1938. After including this variable as a robustness check in several versions of the model, I found that the other independent variables were largely unaffected, except for one: conventional threat. Controlling for post-1938 state creation results in a decrease in the statistical significance of conventional threat to the extent that it is no longer a viable explanator affecting a state's risk of deciding to start a program.
[25] For a thorough explanation of hazard rate, see Box-Steffensmeier and Jones 2004, p. 12-15.

begins to decrease again. Just before thirty years, the probability that a state decides to start a program begins to increase, although the increase is slow, slight, and soon levels off.

If a country has not made the political decisions to pursue nuclear weapons by 1959 or during the first two decades of its independent existence after 1939, then it is less likely to make that political decision later. I have identified the different conditions that may affect the likelihood of making the decision to pursue. The results of the model are shown below.

Table 2.2 Event history model of nuclear weapons program decision making

Independent variable	Coefficient estimate	S.E.
Capacity		
GDP per capita	0.0001	0.0001
Nuclear reactor experience	1.7313**	0.8133
Nuclear civilian assistance	–0.0213	0.0464
Motivation		
Civil-military relations	–0.4002	0.8599
Regime type	0.0001	0.0427
Militarized interstate disputes	0.0931	0.1505
Conventional threat level	0.7292*	0.3846
Strategic rivalry	1.6612*	0.9315
Nuclear strategic rivalry	1.9514***	0.6978
Defense pact	0.4745	0.6496
NPT ratification	–0.1740	0.9193
Model N = 3258		

Note: *significant at p < .10; **significant at p < .05; ***significant at p < .01

Discussion of Results: Capacity Variables[26]

Wealth

[26] More information on the measurement and construction of each independent variable, and the performance of each variable in the event history models, can be found in Appendices 4 and 5.

State capacity to pursue a nuclear weapon program is comprised of wealth, energy, materials, and knowledge. The first measure of capacity, wealth, is needed in order to acquire the latter three. Typically, wealth is operationalized by using some measure of a state's gross domestic product (GDP). In this model, I use GDP per capita as well as GDP per capita squared, in order to account for a possible non-linear relationship between wealth and the decision to begin a nuclear weapons program. Compare two states: one with a great deal of wealth, and another with scarce resources. If the wealthy state experiences an increase in GDP by a given amount, that increase may not have much of an impact on decision making unless it is relatively large. But if the state experiencing scarcity obtains the same increase in GDP that the wealthy state did, that increase will be relatively more meaningful. Squaring GDP makes a unit increase in GDP more meaningful at lower levels of wealth and less impactful at higher levels of wealth.

Regardless of how GDP is measured, however, results show that GDP has no independent impact on a state's decision to start a nuclear program.[27] Since these programs are extremely expensive, why would GDP matter so little? Governments may decide to endure significant sacrifices in order to divert money to a nuclear program. A state may prioritize a nuclear weapons program to the extent that leaders disregard economic constraints. Because nuclear weapons are so highly valued, we should actually expect to find that states at various levels of wealth decide to pursue them. If states desire nuclear weapons strongly enough, their leaders will find a way to pay for them.

[27] Other models of nuclear weapons programs have found occasional support for the hypothesis that wealth makes a state more likely to pursue nuclear weapons. However, in almost every instance where GDP was shown to have a statistically significant effect, the substantive effect has been near zero. See Singh and Way 2004, Jo and Gartzke 2007, and Fuhrmann 2009.

China pursued nuclear weapons despite its limited resources at the time. China's scientific and industrial foundations were not sufficient to support an indigenous nuclear weapons program, and thus the leadership turned to the Soviet Union for assistance with both materials and scientific knowledge. Despite suffering by the population, particularly in the aftermath of the Great Leap Forward, when China endured "three hard years" of rationing, meat shortages, and malnutrition, Marshal Nie Rongzhen, a key figure in the Chinese nuclear weapons effort, persuaded the leadership that developing nuclear weapons would also help develop the Chinese economy.[28] Premier Zhou Enlai proclaimed that China would attempt to produce an atomic bomb within eight years.[29] Funding was diverted to the nuclear program, providing personnel with more food than the general public could procure, and more comfortable living conditions.[30]

China is not the only state that found a way to fund a program it could not comfortably afford. Although Pakistan's low level of economic development in the 1970s could have precluded investment in a nuclear program, Pakistani Prime Minister Zulfikar Bhutto famously declared that the Pakistani population would "eat grass" if that was what was necessary to fund a nuclear weapons program.[31] In Libya, Qaddafi leveraged the country's oil wealth to support his nuclear weapons dream.[32] North Korea has invested in its nuclear weapons program at the expense of its people, who have suffered from periodic famines and energy shortages for decades. Even democratic India spent so much on its nuclear program that its swollen defense budget contributed to bringing about a food

[28] Gill and Medeiros 2010, 139.
[29] Lewis and Xue 1988, 121.
[30] *Ibid*, 123.
[31] Zulfikar Ali Bhutto, statement of October 1965.
[32] Bowen 2006.

shortage.[33] Even in a time of scarcity, a motivated government can find ways to reallocate resources to support a nuclear program.

Nuclear reactor experience

A civilian nuclear program is intended to produce electrical power and distribute it via a power grid. A nuclear power plant is thus considered peaceful use of nuclear technology. However, the same technology used to produce commercial electrical power can also be used to enrich fissile material to weapons-grade. In the early 1980s, the Soviet Union provided North Korea with a graphite reactor, installing it at North Korea's facility in Yongbyon. The reactor itself was a neutral piece of technology, revealing neither peaceful nor militarized intentions. But the reactor was not connected to a power grid. If the reactor was not going to be used to provide electrical power, then why had it been built? This finding immediately raised suspicion regarding the plant's true purpose.[34]

Does a state's peaceful nuclear program increase the chances that the government will make a political decision to start down the path to nuclear weapons? A civilian nuclear program does not necessarily lead to the pursuit of nuclear weapons. Of the fifty-seven countries that have established nuclear reactors, thirty-three have not made the political decision to start a militarized program. But possessing the capacity to operate a nuclear plant may make a country with a peaceful program more likely to someday decide to start a militarized program as well.

Because the same technology can be utilized differently for either civilian or military purposes, familiarity with nuclear power and experience with nuclear science may simply make it easier and less costly for a government to embark upon a nuclear weapons

[33] Perkovich 1999, 69-70.
[34] Mazarr 1995.

program. By operating a peaceful nuclear program, some of the difficulties of starting a weapons program have been mitigated through the accumulation of scientific and technological knowledge and experience, and the acquisition of dual-use technology. Such a state might be at higher risk of deciding to begin a militarized version of their existing nuclear program because the material and knowledge-based costs have been lowered. Furthermore, experience with a nuclear program may increase the confidence decision makers have that a militarized program can be successful.[35]

A state may begin a civilian program with mixed intentions. India is a well-documented case of a government starting a peaceful nuclear program in the full awareness that once the infrastructure and knowledge was in place, establishing a parallel militarized program would be relatively straightforward. Prime Minister Jawaharlal Nehru and nuclear program director Dr. Homi Bhabha spoke both privately and publicly about the potential dual nature of India's peaceful program. In a 1956 speech, Bhabha even went so far as to state that countries with civilian programs could establish parallel programs that would not be subject to international safeguards.[36] The purposeful ambiguity of the Indian nuclear effort demonstrates that gaining civilian nuclear experience can increase the future likelihood of a decision to militarize.

There are also suspected instances of a state deciding to start a civilian nuclear program with the intention of using it to pave the way to a militarized program to be initiated sometime in the future. A state that plans to someday start a nuclear weapons program may decide to begin with a civilian program for two main reasons: to gain experience, and to hide. A civilian program enables a country to develop expertise in

[35] See Fuhrmann 2009 in *International Security*.
[36] Perkovich 1999, 29.

nuclear science, the workings of nuclear reactors and/or reprocessors, and to acquire the materials, machines, and facilities needed, all without triggering the level of alarm from the rest of the world that a weapons program would. A country could use a peaceful program to cloak a future weapons program.

How could such a cloak be effective under the international non-proliferation regime? Non-nuclear weapons states with peaceful nuclear programs agreed, under the Nuclear Non-Proliferation Treaty, to submit to international safeguards intended to track the fissile material used in generating nuclear power.[37] These safeguards are meant to ensure that fissile material is not diverted to enrichment or processing that would make it useable in nuclear weapons. However, safeguards are not foolproof, and they have to be in place to work. Pakistan most likely diverted spent fuel from its KANUPP reactor to its weapons program in the early 1980s. The International Atomic Energy Agency, which is the international body responsible for safeguarding nuclear plants, was not able to fully monitor the reactor for those years.[38] India's Madras I power reactor, which began operating in 1983 and could produce plutonium, was not under IAEA safeguards.[39] North Korea has had a particularly rocky relationship with the IAEA, signing a safeguard agreement but then periodically denying inspectors access to their facilities.[40] Since the IAEA depends on the willingness of the host country to allow monitoring devices to be maintained and inspectors to do their jobs properly, safeguards cannot function in a hostile environment.

[37] Although India, Pakistan, and Israel did not sign the NPT, each country has signed separate safeguard agreements with the IAEA. North Korea signed the NPT but later withdrew.
[38] Spector 1984, 94-95.
[39] *Ibid*, 56.
[40] Reiss 1995.

However, an examination of the available evidence indicates that there are very few cases in which a government initiated a civilian nuclear program with the overarching intention of using it to cloak a military program. Most states that eventually chose to pursue nuclear weapons after beginning a civilian nuclear program either had a purely civilian program at the outset or elected to take a civilian path while leaving the possibility of militarization open (ambiguity).

I test whether a civilian nuclear program increases that risk. I include a variable indicating whether a state has had a nuclear reactor in operation for three or more years.[41] An operating nuclear reactor indicates that a state has a civilian nuclear program that is advanced enough to meaningfully lower the material and knowledge-based costs of developing nuclear weapons.

Table 2.3 Origins of nuclear program

Weapons first	Civilian program first	
China	*Pure civilian*	Argentina
Israel		Brazil
Japan		Iraq
Germany		Pakistan
Libya		South Korea*
Russia		
Switzerland	*Ambiguous*	Australia
United Kingdom		France
United States		India
Yugoslavia		Iran
		Sweden
		Syria
	*Unclear***	North Korea
		South Africa
		Taiwan

[41] Data from Jo and Gartzke 2007, by way of the IAEA's PRIS database.

*As more information on the South Korea case becomes available,
this coding may change to "ambiguous."
**There is not currently enough information available on the timing of these three states' civilian programs to make an assessment.

Nuclear power was first harnessed for electricity in the mid-1950s.[42] The states that started nuclear weapons programs before this period – the United States, United Kingdom, Russia, Germany, and Japan – began their programs in the context of World War II. The use of nuclear power for civilian purposes had not yet been explored when these states started their militarized programs. Removing these cases from the event history model has no meaningful impact on the results.

Table 2.4 Civilian nuclear experience

Countries that started a nuclear weapons program after gaining nuclear reactor experience	Countries that started a nuclear weapons program without nuclear reactor experience
Argentina Brazil France India Iran Iraq North Korea Pakistan South Africa South Korea Taiwan	Australia China Germany* Israel Japan* Libya Russia* Sweden Switzerland Syria United Kingdom* United States* Yugoslavia

*Starred countries began their nuclear weapons programs in the context of World War II, prior to the start of civilian nuclear energy programs.

[42] The Russian plant Obninsk first produced electricity for a power grid in 1954; the British plant Calder Hall, which opened in 1956, was the first commercial nuclear power plant.

The model confirms that a civilian nuclear program does increase the risk of a decision to start a nuclear weapons program. The risk of deciding to weaponize is at least four times as high for a state with a nuclear reactor as for a state without nuclear reactor experience. The difference in the level of risk experienced by nuclear reactor states and non-nuclear reactor states decreases over time, but even so, states with nuclear reactors remain at higher risk of starting a program.

Other measures of capacity, such as advanced metallurgical or chemical capabilities needed for nuclear weapons production, do not have an independent effect on whether a state starts a weapons program. Simple statistical analysis shows that about 90% of the time, a state with a nuclear reactor already possesses the other measure of capacity.

The exception is electrical capacity, measured in terms of whether a state has enough electrical power production to run machines (e.g. centrifuges) and facilities (e.g. reactors or reprocessing plants) needed for a nuclear weapons program. High electrical capacity is also indicative of increased risk of deciding to start a nuclear weapons program. A great deal of electricity is required to power fissile material production facilities, including nuclear reactors, and 99% of the observations of nuclear reactors coincide with a high level of electrical capacity. These observations are not independent of each other.

A government can embark upon a nuclear weapons program without a reactor, and just over half of all nuclear weapons-seeking states have. But only one state – Muammar al-Qaddafi's Libya – has ever decided to pursue nuclear weapons without first having the electrical capacity to run a program, and at the beginning, Libya sought to purchase weapons directly rather than produce them. A state without a nuclear reactor can build or purchase one as long as the electricity is available to operate it. But without that electrical

capacity, there is no justification for beginning a weapons program, and indeed, no state other than Libya has ever made such a decision. Even though a nuclear weapons program cannot exist without a high level of electric power production, actually operating a nuclear reactor for several years still has a slightly more statistically significant effect on the decision to weaponize than does possessing high electrical capacity.

Nuclear Civilian Assistance

From the start, states have provided each other with various types of civilian nuclear assistance, whether in the form of nuclear technology, materials, or knowledge from one country to another for peaceful purposes.[43] Matthew Fuhrmann has argued that civilian nuclear assistance lowers expected costs by increasing a government's confidence that a nuclear weapons program can succeed. Decision makers who believe their country can attain the level of nuclear expertise necessary to create a militarized program will be more likely to proceed down the path of weaponization.

In order to test the hypothesis that civilian nuclear assistance raises the risk that a government will make the decision to start a nuclear weapons program, I include information about the extent to which a state is the recipient of nuclear civilian assistance. I use Fuhrmann's carefully researched list of signed agreements for the provision of this type of assistance. The total number of nuclear civilian assistance agreements a state signed, if that state is the receiving party, is calculated for each year. I find that the level of nuclear civilian assistance has no significant effect on the likelihood of a transition to pursuit. This null result may be due to several factors. A state may have signed an agreement, but receipt of assistance may be delayed or unfulfilled. A state may benefit greatly from black-market

[43] Fuhrmann 2009, 2011.

nuclear assistance or assistance given outside the non-proliferation regime, which would not be captured by an accounting of formal interstate agreements. The model indicates that, within the range of civilian nuclear experience, it is reactor experience specifically that raises the risk of a decision to pursue nuclear weapons.

Discussion of Results: Motivation Variables[44]

Domestic institutions: Civil-military relations

In order to measure how militarized each state's government is in each year, I use the nuanced index compiled by Jessica Weeks (2012). In her study of whether different types of governments are more or less likely to enter into armed conflict, Weeks 2012 measures a "military dimension" as one of two components she uses to categorize states into different types of authoritarian regimes. Not only structural, institutional characteristics, but also the personal experience of the head of state, are measured. The military dimension index serves as a measure of civilian control over the military. For example, a state with a military leader, where the cabinet is populated with military officers, and the military high command is involved with politics, has little civilian control over the military. The higher the index is, the weaker civilian control over the military is.

The event history model indicated that where a government lies on the spectrum of civil-military relations does not impact a state's risk of deciding to start a nuclear weapons program. More militarized governments are neither more nor less likely to choose to initiate a program.

Domestic institutions: Regime type

[44] More information on the measurement and construction of each independent variable, and the performance of each variable in the event history models, can be found in Appendices 4 and 5.

There is agreement in recent quantitative scholarship on the initial state pursuit of nuclear weapons that regime type has minimal to no effect on the likelihood of starting a program. In order to test the effect of type of government here, I use the standard Polity IV index of regime type, ranging from highly democratic to highly autocratic.[45] As discussed earlier, related to the subject of nuclear weapons, both democracies and autocracies may respond to events and to their own citizens in either very different ways or very similar ways. The model confirms that similar domestic institutions, measured as regime types, do not have a common, significant impact on the probability of a state decision to start a program.

The kinds of domestic institutions that are more likely to impact that decision in predictable ways are difficult to measure. Domestic coalitions, interest groups, and political parties may play a role. For states with existing civilian nuclear programs, the goals and influence of the state nuclear agency could affect decision making. Coalitions and interest groups pose particular problems for quantitative coding, as they are difficult to identify and operationalize. Political party platforms and influence may be easier to measure, and the same may be true for the influence of nuclear agencies, although perhaps not the agencies' goals and motivations. Further research may contribute to our ability to model these institutional characteristics.

S*ecurity*

A state's threat environment is made up of different elements that contribute in varying degrees to a government's perception of state security. Individual events like

[45] Marshall, Monty G. and Keith Jaggers. 2002. *Polity IV Project: Political Regime Characteristics and Transitions, 1800-2002*. Version p4v2002e. College Park, MD: Center for International Development and Conflict Management, University of Maryland.

militarized disputes, or verbal threats, or the mobilization of military personnel, are easy to identify, in hindsight, as the proximate cause of a decision to start a nuclear weapons program. But some states experienced threats and events for years before making a decision to start; India and Pakistan are two excellent examples. Many others with fraught security environments have never made the decision at all. Which elements of the threat environment are influential?

Quantitative research is of particular use here. Employing statistical models as one component of an analysis or decision making makes it more difficult for a scholar to engage in post-hoc theorizing, selecting pre-decision security events after the decision has been observed. The clearest cases in which security was the main cause of the decision to develop nuclear weapons are those that began their programs in the context of World War II: the United States, the United Kingdom, Germany, Japan, and finally Russia. Each of these countries pursued the bomb either for possible use in the war or to balance their nuclear weapons-pursuing rivals. But post-war cases are more difficult to assess.

In recent years, nuclear weapons program scholarship has attempted to isolate each of the various elements of the security environment that may prompt states to make decisions regarding proliferation. Jo and Gartzke (2007) examine the effect of conventional and nuclear rivalries separately, while Singh and Way (2004), followed by Kroenig (2009) and Fuhrmann (2009), include whether a state is a participant in a long-term rivalry of either sort. Some have measured the intensity of the security threat, usually calculated based on the militarized interstate disputes a state is involved in (Singh and Way 2004, Fuhrmann 2009). Several authors consider whether a defense pact with a nuclear power

might lead a state away from proliferation (Bleek 2013, Jo and Gartzke 2007, Kroenig 2009, Fuhrmann 2009). I discuss each of these security factors in turn.

Security: Disputes

The militarized activity in which a state is involved, even though it falls short of war, can heighten the state's perception of threat. Conflicts that range from threats to the use of force outside of war may prompt a state to pursue more aggressive defense policies. Following Singh and Way 2004 and Fuhrmann 2009, I calculate a five-year moving average of the number of these conflicts, called militarized interstate disputes, each state is involved in per year. But as states become more involved in conflict, they are not more likely to pursue nuclear weapons. This may be a result of a state's resources being strained by involvement in militarized disputes. Further, as the level of conflict increases, a state may be more likely to focus on improving or expanding the conventional systems that could be utilized in the disputes rather than to begin a long-term, uncertain project that could possibly produce nuclear weapons at some point in the future.[46]

Security: Threat level

With the exception of the two nuclear bombs used to attack Japan in 1945, the nuclear weapons that have been built have not been used. Conflict in the nuclear era has been conducted with conventional weaponry.[47] A state with a more conventionally powerful enemy could choose to bolster its own conventional forces in order to deter an attack or to prepare for military action. However, a strong rival could also prompt the

[46] Another problematic aspect of this measurement is that it does not distinguish between winners and losers. A state may be involved in several militarized interstate disputes, but if that state is victorious in all of them, there would be less reason to pursue a nuclear program than if the state were losing the disputes.
[47] The scarce but ravaging use of chemical weapons is also noted.

weaker state to develop nuclear armaments. In an asymmetric pairing of rivals, the weaker party may believe that nuclear weapons would alter the balance within the rivalry, compensating for a lack of conventional strength.[48] Israel and Pakistan are the most compelling examples of developing nuclear weapons to deter against strong conventional military security threats.[49] However, Pakistan also serves as a reminder that the presence of a strong, asymmetric conventional threat does not necessarily cause the weaker party to turn to nuclear weapons. Pakistan, as the relatively weak state in the India-Pakistan rivalry, responded to Indian conventional superiority for years with its own conventional weapons development, not with a nuclear program.

In the model, the conventional threat a state faces is measured by the ratio of the conventional capabilities of a given states' rivals compared to the state's own conventional capabilities.[50] The results must be carefully interpreted. Meaningful comparisons of risk levels depend on choosing meaningful ratios to compare. I compare risk levels when the ratio is zero (the state has no rivals), the ratio is 1 (the state is equal in power to its rival or rivals), and at different levels when the ratio is greater than 1 (the state has a stronger rival or rivals).

I find that states with relatively stronger rivals are more likely to pursue nuclear weapons. States with weaker rivals are less likely to pursue nuclear weapons for balancing purposes, as the status quo is already in their favor.[51] However, the substantive effect on

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[48] Betts 1987.
[49] Sagan 1996.
[50] This ratio is from Jo and Gartzke 2007 using CINC scores from the Correlates of War project (Singer, Bremer, and Stuckey 1972). More information on the functional form of this measure is in Appendix 4.
[51] Jo and Gartzke (2007) reported conventional threat to be "the most powerful determinant of nuclear proliferation." However, their report is based upon a misleading comparison of threat levels. The values for threat level that they select for this comparison serve to greatly exaggerate the substantive effect of an increase in conventional threat. See Appendix 4 for details.

risk is relatively small. (Of all the statistically significant variables in the model, conventional threat level has the smallest impact by far.) A ratio of 2:1 means that State A's rivals are, all together, twice as powerful as State A, but the hazard rate at that ratio only increases by .25. The hazard rate, which indicates the risk of starting a nuclear program, does not double until the rival(s) possess *five times* the conventional capability of State A.

This level of conventional threat is a threshold; when states face higher and higher levels of conventional threat than a factor of five, the risk of starting a nuclear program continues to rise in great leaps rather than minor hops. For conventional threat to have a meaningful substantive affect on risk, the threat has to be considerably large. And if the two cases considered to be the clearest examples of responding to high conventional threat levels, Pakistan and Israel, are removed from the data set, conventional threat loses its statistical significance while the other variables remain unaffected.[52]

Conventional threats do not appear to drive states to turn to nuclear weapons unless threat levels are extreme; only 2% of all observations fall at or above that threshold ratio of 5:1. The great majority of states in dangerous security environments apparently do not view nuclear weapons as the solution. States tend to choose conventional means to solve conventional problems. When a state's rival pursues or acquires nuclear weapons, however, the decision calculus changes.

Security: Nuclear strategic rivalry

Rivalries between states have been studied as the context for a preponderance of militarized interstate dispute activity and for the majority of wars (Bennett 1998). Studies of "enduring rivalries" – states that have a long history of conflict with each other, and

[52] See Appendix 4 for detailed information on high conventional threat levels by state.

where the conflicts are connected over time – have relied upon dispute history to classify pairs of states into rivalrous or non-rivalrous categories (see, for example, Diehl 1998). Scholars are interested in rivalries because a state is expected to perceive the actions of its rival differently than it would the same actions taken by a non-rival. It is problematic that the potential outcome of rivals' reactions – conflict – is also the measure for determining the existence of a rivalry.

A more theoretically rigorous approach is taken by Colaresi, Rasler, and Thompson (2007) in their analysis of what they term "strategic rivalries." A strategic rivalry can be formed in the absence of any militarized disputes. Instead, rivalries are conceptualized as situations where states have identified each other as competitors, view each other as the source of potentially militarized threats, and perceive each other as enemies. Colaresi et al describe the states in a rivalry as being engaged in a "stream of conflict" rather than being defined by distinct events; the stream of conflict alters the way the states perceive events, so the likelihood increases that even an innocent action will be viewed as provocative. The level and intensity of conflict may vary over time, and periods of conflict may be interrupted by periods of cooperation. Such an expectation of threat and hostility makes conflict de-escalation less likely within a strategic rivalry.

This conceptualization of what it means to be part of a rivalry best matches the dynamic between pairs of states that include one conventionally armed state and one state that is developing or has acquired nuclear weapons. The states not only see each other as enemies, but also as competitors, and as the source of threats that could develop into militarized conflict.[53] If one state in a strategic rivalry began to pursue nuclear weapons,

[53] Colaresi et al 2007.

the rival would perceive this effort as a threat to its own future security. Within the context of the rivals' relationship, such a program would not be seen merely as an abstract problem. Once one state in a rivalry is known to be pursuing nuclear weapons, the dynamic between the rivals is altered. The expectation of threat that was already present now has a terrifying potential outcome.

The non-nuclear member of the rivalry does not need to presume the nuclear striving member would actually use nuclear weapons in war in order to be at greater risk of starting its own program. The non-nuclear state may simply fear that the nuclear striving rival, upon acquiring nuclear weapons, would become emboldened. As a nuclear power, the rival could leverage nuclear weapons to coerce its enemy. A rival with nuclear weapons may become more likely to threaten the non-nuclear state, and to carry out its threats *by conventional means*, believing that it can rely on its nuclear arsenal to trump any response. The specter of an emboldened nuclear rival, newly willing to employ its conventional armed forces to achieve long-held objectives, could be enough to lead the non-nuclear member to start down the path to the bomb.[54]

A strategic rivalry with one nuclear weapons striver or power could thus create the conditions to set in motion one step of a "strategic chain reaction," as Sagan (1996) describes the concept of one state's nuclear ambitions spurring on its competitors to follow suit. To test whether states with "nuclear strategic rivals" – rivals that are pursuing or have acquired nuclear weapons – are at greater risk of starting their own nuclear weapons

[54] One possible argument against the mechanism described here is that states are not able to detect their rivlas' secret nuclear programs. However, in most cases, the historical evidence does support the proposition that states have typically learned of their rivals' programs within the first one to two years, well before weapons were actually built or tested. Rivals engage in robust intelligence-gathering efforts that often provide them with early information about nuclear programs.

programs, I create a list of nuclear strategic rivalries. The list is composed of non-nuclear weapons seeking states with at least one nuclear strategic rival.

Two simple but interesting facts emerge from a cursory examination of this list. First, fourteen out of the thirty-two states with a nuclear strategic rival – almost half – eventually began their own nuclear weapons program. Second, fourteen out of the twenty-four states that began a nuclear weapons program first had a nuclear strategic rival.[55] More than half of all nuclear weapons pursuers had nuclear strategic rivals prior to making the political decision to pursue.

Table 2.5 Nuclear Strategic Rivalries 1938-2009[56]

Country	Nuclear Strategic Rival	Years
Afghanistan	Pakistan	1972-ongoing
	Iran	1996-2001*
Angola	South Africa	1974-1988
Argentina (1976)	United Kingdom	1965-ongoing
Brazil (1979)	Argentina	1976-1985
Bulgaria	Yugoslavia	1947-1955
Chad	Libya	1969-1994
Chile	Argentina	1976-1991
China (1955)	Japan	1943-1945
	Russia	1943-1949
	United States	1949-1972
Cuba	United States	1959-ongoing
Egypt	Iraq	1971-ongoing
	Israel	1956-ongoing
	Syria	1979-1990
	Libya	1973-1992
	Iran	1979-ongoing
Germany (1941)	United Kingdom	1941
Greece	Yugoslavia	1947-1953
India (1964)	China	1956-ongoing

[55] I determine that twenty-seven states have possessed a nuclear weapons program at some point in time, but three of those – Belarus, Kazakhstan, and Ukraine – inherited their programs after the breakup of the Soviet Union. These states did not ever make political decisions to start nuclear weapons programs, and so I exclude them from this analysis.

[56] Strategic rivalries are based on William R. Thompson and David Dreyer, Handbook of International Rivalries, 1494-2010 (Washington, DC: CQ Press, 2011). Timespan of nuclear strategic rivalries are based on my assessment of the year a rival's nuclear weapons program began.

Country	Nuclear Strategic Rival	Year
Iran (1974)	Iraq	1971-ongoing
	Israel	1979-ongoing
Iraq (1971)	Israel	1956-ongoing
Italy	United Kingdom	1947-1954
	Yugoslavia	1941-1945
Japan (1943)	United Kingdom	1941-1945
	United States	1942-1945
	Russia	1943-1945
Jordan	Israel	1956-1994
	Syria	1979-ongoing
Kuwait	Iraq	1971-ongoing
Mozambique	South Africa	1976-1989
Pakistan (1972)	India	1964-ongoing
Russia (1943)	United Kingdom	1941-1956
	Germany	1941-1945
	Japan	1943-1945
Saudi Arabia	Iraq	1971-ongoing
	Iran	1979-ongoing
South Korea (1971)	North Korea	1968-ongoing
Sudan	Libya	1973-1985
Syria (1979)	Iraq	1971-ongoing
	Israel	1956-ongoing
Taiwan (1967)	China	1955-ongoing
Turkey	Syria	1947-2004
United Kingdom (1941)	Germany	1941
United States (1942)	Germany	1941-1945
Vietnam	China	1973-1991
Zambia	South Africa	1974-1989
Zimbabwe	South Africa	1980-1989

Notes:
1. **Bold** type means that the country eventually began a nuclear weapons program of its own.
2. An asterisk (*) means the rivalry is not recorded in the data set, which ends in 1992.
3. The years listed are only the years of the *nuclear* strategic rivalry, and in many cases do not encompass the entire duration of the two countries' strategic rivalry.

Do nuclear weapons seekers put their strategic rivals at greater risk of starting their own programs? There is exceptionally strong support from the model indicating that they do. The risk of starting a program is ten times as high for a state with a nuclear strategic rival than for a state without this type of rival. Of all the competing explanations tested, a

nuclear strategic rivalry renders the largest substantive impact by far on the risk of pursuing nuclear weapons. Furthermore, its predicted impact is supported by a very high level of certainty within the event history model; it is consistently the most statistically significant variable across multiple versions of the model.[57]

The Indian decision to pursue nuclear weapons illustrates how a nuclear strategic rival puts the non-nuclear rival at greater risk of starting a program. While India's strategic rivalry with Pakistan has influenced Indian nuclear weapons development and strategy over the last three decades, India did not face a strong security threat from Pakistan during the time when the decision to pursue nuclear weapons was made.[58] China, India's strategic rival for more than half a century to date, was a key factor in the Indian path to nuclear weapons.

China's nuclear weapons program was public knowledge by 1958 at the latest, when the Chinese foreign minister publicly revealed China's intentions to foreign press.[59] Over the next several years, long-standing border disputes between India and China would escalate, then stagnate, then escalate again. By 1962, China had rejected an Indian proposal to reduce tensions and plan negotiations, and both sides prepared for war.[60] Initial forward troop movements by China intensified over the late summer and early fall, and in late October, China launched attacks in disputed border areas that quickly resulted in victory over India.[61]

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[57] Even which all strategic rivalries are also included in the model, nuclear strategic rivalry remains the most significant variable with the most substantively large impact, with the risk of starting being seven times as high for states with nuclear strategic rivals.
[58] Perkovich 1999, Spector 1971.
[59] Perkovich 1999, 43.
[60] *Ibid*, 44.
[61] Ibid.

Yet despite three years of conflict with China, and ultimately a defeat, the government of India did not make a political decision to develop nuclear weapons. Instead, India's response was to double the defense budget, allocating significant resources to conventional military spending. Reflecting on China's handy victory over Indian forces, Prime Minister Nehru stated, "We were getting out of touch with reality in the modern world."[62] Nehru turned not to nuclear weapons, but to building up and modernizing India's conventional armaments and armed forces.

The risk of India deciding to start a nuclear weapons program continued to increase. Nehru chose to continue to hold nuclear weapons at arm's length, continuing India's civilian nuclear program under the authority of Dr. Homi Bhabha, a nuclear scientist who held out hope that he would one day be permitted develop weapons. But political support for nuclear weapons began to grow, concomitant with citizens' fears over China's intentions and military might.[63]

When China detonated its first nuclear weapon on October 16, 1964, the seeds of a decision, planted over the years of the Sino-Indian nuclear strategic rivalry, now bore fruit. The political push for India to create its own indigenous nuclear weapons program intensified. Dr. Bhabha, now secretary of the Department of Atomic Energy, seized this window of opportunity to make a public call for the militarization of India's nuclear effort. Days later, India's prime minister of only a few months, Lal Bahadur Shastri, made the decision to authorize a nuclear weapons program.[64]

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[62] *Ibid*, 46.
[63] *Ibid*, 47.
[64] *Ibid*, 67-70.

India's strategic rivalry with a nuclear weapons-pursuing, and eventually nuclear weapons-capable, state, was fraught with militarized disputes from threats to actual conflicts. This nuclear strategic rivalry did not immediately cause India to start its own nuclear weapons program. However, China's nuclear pursuits, within the context of the Sino-Indian rivalry, placed India at higher risk of pursuing its own program. Indian officials, and the Indian public, were aware of China's nuclear weapons program and concerned about China's strategic intentions toward India. Less than a decade into the nuclear strategic rivalry, India was ready to make the decision to start upon learning of China's successful nuclear test.

Security: Defense pacts

States may rely on other, more powerful states to augment their security. Until the collapse of the Soviet Union in 1991, the post-World War II nuclear weapons era coincided with the Cold War, a period dominated by the "superpowers" of the United States and Soviet Union. Many states aligned militarily with one of the two patron states, whether for protection, for assistance in improving the smaller state's military and weaponry, or both. Those that entered into defense pacts with one of these nuclear-armed superpowers, and thus received assurances of protection, may have had less of an incentive to develop their own nuclear weapons programs.[65]

However, analysis reveals that defense pacts do not lower a state's risk of deciding to pursue nuclear weapons. Several alternative lists of defense pacts with nuclear states exist. Regardless of which list I use in the event history model, defense pacts do not affect

[65] See Bleek 2013.

the risk of deciding to start and program. Security guarantees are not truly viewed by protégés as guarantees after all.

A protégé may not be convinced that the protecting nuclear power really would honor the defense pact if it meant using their nuclear arsenal and thus inviting nuclear retaliation. Attributed to French President Charles de Gaulle is the question of whether, in the event of a Soviet nuclear threat, the United States would truly risk New York to save Paris. North Korea had similar concerns about their nuclear protectors. Kim Il Sung signed defense pacts in 1961 with the Soviet Union, which had already developed nuclear weapons, and with China, which at that time had a well-known nuclear weapons program. However, North Korea's fears of the new military government in South Korea persisted, and the country decided to start its own nuclear weapons program.[66] Skeptical protégés will be unwilling to depend upon a security guarantee from a nuclear protector, and their risk of developing nuclear weapons will not be change.

Prestige

Separating the desire for prestige from other factors that contribute to the decision to start a nuclear program is a difficult matter. In a few cases, speeches, writings, or other evidence can be used to indicate that the leadership considered prestige to be an important outcome of acquiring nuclear weapons. However, clear evidence is lacking in most case histories. Identifying concerns for prestige apart from concerns over security is also problematic. For example, a humiliating military defeat may simultaneously inspire a government to improve state security and repair the state's reputation.

[66] Mazarr 1995.

Including a normative concept like prestige in a statistical model is challenging. Norms change over time, but it is difficult to pinpoint when, and how much. Sagan (1996) argues that prestige in nuclear affairs changed between the 1960s and 1990s: In the early years of nuclear weapons programs, nuclear bombs were prestigious symbols of advancement, strength, and modernity. By 1990s, however, becoming a part of the non-proliferation regime, as evidenced by ratifying the Nuclear Non-proliferation Treaty (NPT), lent prestige to the ratifying state as a legitimate, responsible member of the international system.[67] But when did the norm begin to change? And when did it change enough to affect the behavior of states? And it appears that the norm of nuclear weapons as a symbol of modernity has not changed to the extent that many have hoped, as states like Iran and North Korea continue to pursue nuclear weapons programs despite international condemnation.

I estimate models both with and without information on when each NPT member ratified the treaty.[68] NPT ratification has no effect on risk of starting a nuclear program.[69] This is unsurprising, given the makeshift nature of the measure. Although the prestige of nuclear weapons has certainly been a factor in some leaders' decision making, the tools to comparatively analyze prestige in this model do not currently exist. Using the NPT to measure prestige is theoretically unsatisfying. More work must be done to develop sound comparative measures of nuclear norms.

Conclusion

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[67] Sagan 1996.

[68] I estimated models without the NPT variable because I agree with the excellent point made by Singh and Way (2004). Including NPT ratification in a model introduces "obvious and substantial endogeneity," meaning that one cannot tell whether ratifying the NPT makes states less likely to pursue nuclear weapons since the vast majority of ratifiers did so because they never intended to pursue nuclear weapons in the first place.

[69] Non-ratification, or withdrawal from the NPT,

Both capacity and motivation affect the probability that a state will decide to start a nuclear weapons program. States with nuclear reactor experience have jumped one of the highest hurdles en route to developing nuclear weapons: they have acquired a tremendously expensive and technologically advanced facility that can produce the fissile material needed for atomic bombs. Nuclear scientists and engineers in the country have accumulated concrete knowledge of, and hands-on experience with, the process of nuclear fission. Decision makers feel more confident that a nuclear weapons program would have a reasonable chance of success.

Certain aspects of the security environment provide states with motivation to pursue nuclear weapons. A conventional military threat to a weaker state, although not as important as previously thought, does matter at very high threat levels. If a state has a nuclear strategic rival, the probability that the state will start its own nuclear weapons program rises substantially, whether the rival already possesses nuclear weapons or is still only attempting to acquire them. Finally, while it seems clear that the desire for prestige plays a role, the means to model evolving norms do not currently exist.

The decision to start a nuclear weapons program is merely the first step in a long march to the bomb. The path to acquiring nuclear weapons varies widely across states. Some states launch crash programs to quickly develop a nuclear arsenal; others slow the pace of their programs, before or after acquiring weaponry. Still others decide to end their nuclear weapons programs altogether. The conditions under which states are more likely to choose to start programs are different from those affecting states along the nuclear path. We turn now to the impacts of civil-military relations (Chapter 3), and of the autonomy of

nuclear agencies (Chapter 4), on the decisions states make once they have begun their nuclear programs.

CHAPTER 3

The Path and Pace of Nuclear Weapons Programs:

Civil-Military Relations

Do military governments make fundamentally different decisions about nuclear weapons programs than those that are made by civilian governments? Why might civilian control over the military make a difference in this type of decision making? And how could we discover whether it actually does?

A state's external security environment can affect that state's decision to pursue a nuclear weapons program, as we found in Chapter 2. Facing a major security threat increases the state's likelihood of deciding to pursue such a program. However, once that program has begun, the state may make many different types of decisions regarding the nature and use of the program. If the state acquires nuclear weapons, military and civilian leaders may discuss whether and how the weapons should be deployed, and in what circumstances they may be used. Tactical decisions regarding deployment, and strategic decisions regarding nuclear doctrine, are made by only a handful of states: those that have joined the nuclear weapons "club." These decisions are made because the state already possesses nuclear weapons. The path a state takes as it pursues and develops nuclear weapons is lined with decisions of a different sort. When, and why, a government decides

to push a program forward or hold it back is much less dependent on the threat environment. Instead, the proliferation pathway is heavily moderated by domestic institutional factors. One of those factors is the state's civil-military relations.

Civilian control over the military varies from state to state; in some cases, it is weak or non-existent, and in others, civilian control is firmly in place. This variation occurs across different regime types. Not all democracies have strong civilian control over the military, and not all autocracies fall on the weak civilian control end of the spectrum. Even among the small subset of nuclear weapons-seeking states, there are several democracies that have experienced periods of weaker civilian control over the military, including the United States during the Cold War. For non-democracies, both the Soviet Union and Yugoslavia established strong civilian control of the military. Since the Iranian Revolution, Iran's civilian government has maintained strong control of the military during times of both relative autocracy and democracy.

More cross-national, comparative work needs to be done in examining common factors that contribute to the development of these different types of civil-military relationships. A country's existing political institutional structures, bureaucratic culture, military history, threat environment, strategic philosophies, and societal norms regarding peace and conflict may all contribute to the state of civil-military relations. But as Vipin Narang points out in his forthcoming (2014) work on nuclear posture, we can observe that civil-military relations have an independent effect on state behavior. States with similar regime types and in similar security environments can have different civil-military structures. (Among states that have sought nuclear weapons, this is most noticeable among the pairings of China and Russia, Iran and Iraq, and North Korea and South Korea.) And

institutionalized civil-military structures are part of the mechanism of foreign and defense policy making. The extent to which the military enjoys autonomy from civilian leadership affects the way a government manages and prioritizes its military and security affairs.

Using statistical models and case studies, I examine the effect of various levels of civilian control over the military on state decision making regarding nuclear weapons programs. States with weaker civilian control of the military *do* make different proliferation decisions than states with stronger civilian control; in fact, they are less likely to make decisions to push a program forward. The more militarized the government is, the lower the risk that the government will decide to accelerate a nuclear weapons program. Military decision making is more likely to focus on what is best for the military and less on what is best for the country's broader interests – even its security interests.

In this chapter, I begin with an overview of how civilian control over the military varies by examining civil-military relations in India, France, China, and Pakistan. Next, I describe the organizational preferences militaries tend to hold. I then propose a theory explaining why militaries are less likely to accelerate nuclear weapons programs that depends on beliefs and preferences. Finally, I test the theory using an event history model and find that the data confirm that the weaker civilian control of the military is, the less likely the state is to make an acceleration decision.

Civilian Control over the Military: Strong to Weak

Civilian control over the military varies widely, even within the subset of states that have pursued nuclear weapons programs. When civilian control over the military is high, the military almost always has little influence in nuclear program decision making, relative

to states with weak civilian control. Institutional differences among nuclear weapons-seeking states become apparent as one moves along the civil-military spectrum from strong to weak civilian control.

Strong: India and France

India, which began its nuclear weapons program in the 1960s, maintains strict civilian control of the military. When India achieved independence from Great Britain and established national domestic institutions, the military was deliberately excluded from national security decision making and has historically had a small and limited role in nuclear policy making. Not only was the civil-military relationship designed to keep the military separate from security policy institutions, but the societal status of military officials differs from that of the civilians who lead and operate the nuclear weapons program. In India's persistent *jati*, or caste, system, scientists are almost exclusively Brahmins. Military personnel, including high-ranking officers, come from lower social classes and are considered to have a lower social and professional status than scientists.[1] This distinction further quiets the voice the Indian military has on nuclear matters.

In France, a similar class separation reinforces the military's subjugated role in the civil-military relationship. Clear civilian control over the military is a hallmark of French foreign and defense affairs. The French Finance Minister has significant power to shape programmatic choices, including the authority to override defense spending decisions.[2] While the military is involved in nuclear affairs, the political and social elites in the French

[1] Perkovich 1999.

[2] The nuclear agency that has been the most important in French nuclear policy, the Comissariat à l'Energie Atomique (CEA), was further insulated from military control, and even from political control: the CEA is not subject to the same financial controls as other state agencies and is accountable directly to the Prime Minister. See Hecht 1998.

system are civilians. France's premier university for government and public policy is the Ecole nationale d'administration, or ENA, and the public servants educated there are called "les énarques." Those educated at the preeminent science and engineering university, the Ecole Polytechnique, are known as "Xs," a reference to the university's nickname of "X." Those with the ENA pedigree are afforded great status and privilege in the French government; France is essentially administered and led entirely by énarques. Together, the énarques and Xs have always been the "in group" in nuclear affairs, with the military solidly in the "out group."[3]

Moderately weak: People's Republic of China

Weak or absent civilian control of the military is often characterized in part by overlap between civilian and military institutions. High-ranking military officials may hold prominent and powerful posts in national politics or domestic policy institutions. There may be a lack of clarity over whether it is the civilian or military leadership that ultimately has the authority to make state decisions on foreign policy and security matters. The board or other governing body of the nuclear weapons agency is likely to be led by military officials, or at least to have senior military officers serving at executive levels. At the extreme end of the spectrum, the military may enjoy exclusive authority over foreign and defense policy, and may prevent civilian authorities from participating in policy making, or even from learning of the state's most basic security activities, including the nuclear weapons program.

Less strong civilian control of the military has led to significant military influence on nuclear decision making in the People's Republic of China. China's nuclear and defense

[3] McLean 1986.

bureaucracy has undergone a great deal of change and restructuring since the advent of the Chinese nuclear weapons program. With the ascent to power of Deng Xiaoping in 1978, China embarked upon a widespread process of demilitarization that promoted conventional military tools and deemphasized nuclear weapons. The People's Liberation Army's (PLA) political role as defender of the 1949 Chinese revolution shifted to a focus on defense of the country.[4] Power over programs like the nuclear weapons program shifted from various agencies to the general staff of the PLA.[5] China became more bureaucratic, and the careers of PLA officers became more stratified.[6] Yet even with these changes, China's place on the civil-military relations spectrum has remained fairly consistent. The military establishment of the PRC has always been subordinate to the Party, but this control has historically been slightly weak.

This weak control is most visible in the intertwining of the top leadership of the People's Liberation Army (PLA), the other branches of the armed forces, and the Communist Party.[7] This was especially true during the formative years of Chinese nuclear weapons development, when decisions were made by leaders who moved fluidly among Party, military, and scientific spheres. Further, military officers were often trained in science and technology and even made important scientific contributions; weapon scientists received military rank until the late 1990s.[8]

These "symbiotic party-army relations" enabled leaders to exercise both military and political influence.[9] Overall, however, the Communist Party has ultimate authority.

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[4] *Ibid*, 201.
[5] Feigenbaum 2003, 123.
[6] *Ibid*, 120.
[7] McLean 1986, 189.
[8] Gill and Medeiros in Born 2010, 134.
[9] *Ibid*, 133.

Assessing the power, organization, and roles of the myriad agencies that comprise the dense civil-military structures in the PRC is no simple task. Early nuclear weapon development decisions were shaped by several key military leaders, including Marshal Nie Rongzhen, Marshal Peng Dehuai, Marshal He Long, and General Zhang Aiping.[10] A brief survey of the military and civilian career of the first man named on that list and a key figure in the development of Chinese nuclear weapons, Marshal Nie, provides a glimpse into the civil-military relationship.[11] Nie, a hero of the Communist revolution against Nationalist Chinese forces that brought Mao Zedong to power in 1949, became the Mayor of Beijing and the acting chief of staff of the army. He was simultaneously Deputy Prime Minister (1956-1974) and the head of various commissions and bureaus leading the nuclear weapons effort.

In 1955, Nie was appointed to a Three-Member Group that reported directly to the Politburo and was tasked with directing policy for the nuclear weapons program. The other two members were a leading Politburo member and an economic minister who was a rising star in the Party; Nie was the military presence.[12] When the nuclear program was restructured in 1956 and the group dissolved, Nie, who was already the head of the defense industry and equipment program, also became the head of the Scientific Planning Commission. He was now running both the defense industry and scientific nuclear programs and, as vice-premier, became Premier Zhou Enlai's right hand regarding scientific and technical policy making.[13]

[10] Ibid.
[11] I am indebted to Lewis and Xue's (1988) fascinating history of China's nuclear weapons program.
[12] Lewis and Xue 1988.
[13] *Ibid*, 51.

In 1958, Nie proposed merging two state scientific and technological commissions into one, and then became its director. This commission was established by the Party and was not a governmental agency, which allowed it to mobilize resources and to command "virtually at will."[14] During this time, Nie was also a vice chairman of the powerful Central Military Commission (CMC) of the Communist Party.[15] Nie later recommended that two defense agencies be merged into one new one, and he became the director of that new agency as well.[16]

Nie Rongzhen's commission commanded the nuclear weapons and missile program, which functioned as a civilian industrial system under military control. Those who worked in the nuclear weapons program were not members of the military and did not wear uniforms, yet they answered to the military. Until 1965, workers in the missile program were assigned to the PLA and wore uniforms. Specialists in aircraft and warship research and development also wore uniforms, but reported to Nie's commission. Production personnel did not wear uniforms and reported to the National Defense Industry Office, a powerful civilian agency engaged in a rivalry with Nie's civil-military empire.[17]

Ultimately, Nie was, for a time, able to control the scientific and technical resources of the PLA, the State Council's military industrial system, and the defense-related sciences of the Chinese Academy of Sciences, in areas relevant to nuclear weapons.[18] Reporting directly to the Central Military Commission – and recall that Nie was a vice chairman of the CMC – Nie blended his civilian and military roles in consolidating his authority over nuclear

[14] Feigenbaum 2003.
[15] *Ibid*, 120.
[16] Lewis and Xue 1988, 54.
[17] *Ibid*, 59.
[18] *Ibid*, 54.

affairs. His resulting influence on the nuclear weapons program is one outcome of the overlap between civilian and military institutions in China. Further along this spectrum of civil-military relations is the case of Pakistan, where a military coup led to the long-term lack of civilian authority over military affairs.

Very Weak: Pakistan

For the first decade of the Pakistani nuclear weapons program, the military stayed on the periphery. Military personnel assisted with security, or with building new sites needed for the program, but the military was not involved with policy making and had relatively little influence. One scholar describes the period leading up to the 1977 military coup as characterized by "exclusive" civilian control over the nuclear weapons program.[19]

This changed when Muhammad Zia-ul-Haq, a four-star general and Chief of Staff of the Army, seized power in 1977. The army became the dominant force in Pakistani politics (and became a tool for political repression), and that shift to military control has had institutional repercussions that far outlasted Zia's eleven-year tenure as head of state. The military began exercising control over the nuclear weapons program, securing its power there to the extent that even after Zia's death in 1988, succeeding civilian heads of state could not access information on the program, or even visit sensitive facilities.[20]

Executive leadership in Pakistan passed again under direct military control, via military coup once more, with the presidency of General Pervez Musharraf in 2001. Under Musharraf, the militarization of the Pakistani nuclear weapons program increased yet again. The previous year, an organization called the National Command Authority (NCA) was established to supervise nuclear weapons research and development, as well as the

[19] Zafar Iqbal Cheema in Born, Gill, and Hänggi, 2010
[20] This will be discussed in more detail later in the chapter.

military services that operate the strategic forces. Although the Prime Minister of Pakistan had been designated as the chairperson of the NCA, Musharraf had become its chair, and then stayed on in this position after ascending to the presidency.[21]

The NCA includes powerful civilian and military officials, among them the chair of the Joint Chiefs of Staff, the Ministers of Defense, Interior, and Finance, the Director-General (who is a military general) of the Strategic Plans Division, and the Commanders of the Army, Air Force, and Navy. It is Pakistan's main decision-making body for nuclear weapons issues.[22] As part of Pakistan's Strategic Command Organization, the NCA sits alongside the Strategic Plans Division (SPD), which is part of the same organization and is led by a military general. The SPD formulates nuclear policy, strategy and doctrine; the NCA and SPD both handle operational planning. The SPD is actually the secretariat for the NCA. It oversees PAEC (Pakistan Atomic Energy Committee) and KRL (Khan Research Labs), which are the two nuclear research laboratories in Pakistan.

Although the NCA reverted to civilian leadership in 2009, when the incoming president named his prime minister as chair, that return to the original institutional design of the agency was seen by many as symbolic. Executed under Musharraf, the December 2007 Ordinance to Provide for the Constitution and Establishment of the National Command Authority strengthened the power of the military-run SPD and further institutionalized the military's strong control over the system.[23] Michael Krepon likens the Director-General of SPD, Lt. General (ret.) Khalid Kidwai, to the United States' Admiral

[21] Kerr and Nikitin 2012.
[22] Medalia 2011.
[23] Kerr and Nikitin 2012.

Rickover: Kidwai has enormous influence and has been Director-General since 2001.[24] As scholar Zafar Iqbal Cheema has written, democratic institutions are still maturing in Pakistan. In that country, it is the military that is the professional organization with experience.[25]

Military Organizational Preferences

Much of the disagreement regarding how governments with weak civilian control over the military behave differently from strong civilian governments can be summarized by this question: On matters of war and peace, when a state faces a decision of whether to engage in conflict, is military culture aggressive and risk-loving, or cautious and risk-averse?[26] Because of the military's role in protecting the state, and the subsequent need for discipline and unity, military training socializes soldiers, imbuing them with commonly held beliefs about conflict and the use of force. This is not to say that all soldiers think alike, nor that inexperienced, low-level military personnel must share the same patterns of thought and action as high-ranking career officers. But commonly held perspectives on war and peace persist among professional, state militaries.

Some scholars argue that militaries have organizational interests that are served by going to war. Alfred Vagts theorized that soldiers not only seek glory and adulation for their heroic exploits in war, but also that militaries would view wars as ways to justify

[24] From a post on Arms Control Wonk (armscontrolwonk.com), 3 June 2013.
[25] In Born et al 2010.
[26] A notable recent exception is Todd Sechser's 2004 study of civilian versus military aggression when it comes to the decision to engage in conflict. He finds that states with weak civilian control over the military are more aggressive, not because all militaries tend to be more aggressive than civilian leaders, but because more aggressive militaries develop in states with weak civilian control.

higher spending on defense.[27] Countering the militarism theory, Samuel P. Huntington argued in his classic 1957 book, *The Soldier and the State*, that militaries tend toward caution, only rarely advocating involvement in conflict. War, with its inherent uncertainties and risks, threatens state security, and securing the state is the military's chief objective.[28]

In the U.S. case, there is empirical evidence that civilians are relatively less conservative about the use of force than are soldiers. Feaver and Gelpi used survey data to assess the size of the gap between civilian and military attitudes in the United States. While there exist "pockets" of interventionist soldiers and dovish civilians, overall, the authors identified a systematic tendency for civilians to be more bellicose than military personnel.[29] Soldiers have a greater understanding than civilians of the human and material costs of war and the risks involved in conflict, and they respond to questions regarding the use of force with more caution and less optimism. The results are most applicable to the behavior of elites, who are most likely to be decision makers.

However, there is also plenty of evidence, mainly anecdotal, of aggressive, war-seeking militaries. Staying with the U.S. case, one need look no further than General Douglas MacArthur or General Curtis LeMay for examples of military decision makers who were eager to pursue battle and who had to be restrained by civilian leaders. Scott D. Sagan, among others, argues that military officers often have biases in favor of the offensive

[27] Alfred Vagts. 1937. *A History of Militarism*. New York: Norton.
[28] Whether states seek opportunities for war has been part of the nuclear proliferation discussion mainly in terms of whether nuclear weapons states will become emboldened by the devastating power of their weapons and thus more likely to go to war. For example, see Michael Horowitz, "The Spread of Nuclear Weapons and International Conflict: Does Experience Matter?" in *Journal of Conflict Resolution* 2009, vol. 53, no. 2.
[29] Feaver and Gelpi 2004.

use of force.[30] This preference may develop from the interests that military organizations have, which do not necessarily conform to the interests of the state as a whole. Officers are motivated to protect their own organizational capacity, influence, and ability to make policy. A larger budget and staff, for example, further the military's ability to achieve its goals.[31] An orientation toward offensive strategic thinking is arguably also in the best interests of the state; wars are not won defensively. Military personnel acting to secure the state should be inclined to pursue weapons systems that can be used offensively.

Whether militaries are aggressive or conservative should affect how likely militaries are to seek out opportunities to engage in conflict with other states. A risk-loving military should, for example, make more aggressive choices about how nuclear weapons are deployed and readied than a risk-averse military. Militaries' preferences regarding the course of a nuclear weapons *program*, however, do not depend upon this militaristic-conservative framework.

Most scholarly work on civil-military relations and nuclear weapons has concerned management of the state's nuclear weapons arsenal. Scott Sagan argues in his published "debate" with Kenneth N. Waltz that military or weak civilian governments might lack the oversight and discipline needed to prevent accidental or intentional nuclear war. Without the checks and balances of civilian control, a military government would make fundamentally different decisions due to the unique characteristics and interests of military organizations.[32] Vipin Narang analyzes civil-military relations and the operational

[30] See, for example, Jack Snyder's *The Ideology of the Offensive* (1984) and Barry R. Posen's *The Sources of Military Doctrine* (1984).
[31] Sagan 1996.
[32] See Sagan and Waltz, 2003 for a discussion of military institutional characteristics such as operations-driven planning and a tendency toward inflexibility.

nuclear doctrine of regional powers to determine why states adopt different nuclear postures, and why some nuclear postures change over time.[33]

The difference between nuclear posture and nuclear weapons program is fundamental. The nuclear weapons program is the research, development, testing, and production effort that may or may not lead to the acquisition of nuclear weapons. Nuclear posture concerns the state's nuclear force structure; in other words, a state must possess a nuclear arsenal in order to adopt a nuclear posture. The number and types of weapons, the procedures and structure of how those weapons are managed, and the way in which the state has arranged its weapons for possible use, all comprise a state's nuclear posture.[34] If nuclear warheads are separated from delivery systems and housed in different facilities, for example, a state is assuming a less aggressive posture than if the weapons were fully assembled and standing on missile launch pads.

In many states, some of the same civilian political leaders make the decisions regarding both program and posture, but it is clear that program and posture are distinct concepts. If a militarized threat were to emerge, the threatened state's nuclear posture would be reviewed and possibly altered relatively quickly: perhaps within a few weeks, or even within a few hours. A decision to change the operational status of nuclear weapons would be quickly implemented by trained military professionals, each with his or her own defined, practiced role.

Programmatic decisions, on the other hand, involve long-term plans, may incur very high costs, and are implemented within bureaucratic structures that require time to adapt. Such changes are often made in secret, and other states may not learn about these

[33] Narang 2014.
[34] Ibid.

decisions until years later. For example, in 1985, Iran made the political decision to pursue an indigenous uranium enrichment capability by way of a gas centrifuge program. This decision to accelerate the nuclear program, when had been resurrected only about a year earlier, did not involve nuclear posture, as Iran had no nuclear arsenal to arrange or manage. The head of the Atomic Energy Organization of Iran then had to solve the problem of how to accomplish this task, ultimately turning to the black market to obtain the needed equipment.[35] Getting the enrichment program up and running took years. This long-term, high-cost decision had nothing to do with the arrangement or use of nuclear weapons, as Iran did not possess a nuclear weapons arsenal. It was solely a programmatic decision intended to change the pace of nuclear weapons development.

Civil-military structures can affect programmatic decision making. If civil control of the military is weak, the organizational interests of the military will more heavily influence, or even determine, the decision made. Militaries' preferences regarding the course of a nuclear weapons program do not depend upon the militaristic-conservative framework that is useful in thinking about aggression and posture. Decisions about program are fundamentally different than decisions about posture and use. But organizational interests will drive the military's position on the course a nuclear weapons program should take, as the military's desire for autonomy and influence should exist regardless of whether that military is relatively risk-averse or risk-loving.

Civilian control of the military will either constrain or free military leaders to pursue their own organizational preferences. Does it stand to reason, then, that states with weaker civilian control of the military will exhibit more fast-paced and well-funded nuclear

[35] Patrikarakos 2012.

weapons programs punctuated by more frequent decisions to ramp up weapons development? I argue the contrary: that more militarized states are *less* likely to decide to accelerate the development of nuclear weapons. I propose six reasons why: Militaries have traditional interests, work to build arsenals, are inwardly focused, strive to minimize civilian interference in military affairs, desire prestige, and believe that nuclear weapons are unusable.

Traditional Interests

Modern, professional militaries are enormous, complex organizations. Different branches of the same military compete with one another for resources; more new ships for the Navy may mean fewer new planes for the Air Force. And the military as a whole competes with other governmental organizations for resources. Organization theory calls the interests of militaries "parochial interests," meaning that the military cares not just about the external goal, which is the security of the state or the success of the mission, but also about its internal goals, chief among them its own survivability. Decision making within the military organization is likely to focus on what is best for the military, even if that decision may, at times, be made at the expense of the state.

The driving organizational preferences of militaries derive from traditional military interests. Militaries are centered around soldiers, not around nuclear weapons. Nuclear weapons are merely one component of a modern military establishment. A military made up of nuclear missiles, or nuclear gravity bombs to be dropped from aircraft, would essentially be a rocketry force or an air force, something which armies and navies would strenuously oppose. Officers in policy and decision making roles have more to consider than state security when making a major decision about the allocation of resources. New

programs may siphon funding from existing ones. They may garner influence and prestige, causing a relative decrease of those characteristics of the established programs. Officers who have spent their careers carving out their bases of power within the vast military bureaucracy may see organizational change as a zero-sum game and will be unlikely to support or promote new spending, staffing, and programming that will detract from their own holdings.

An example from the U.S. military illustrates the pull of traditional interests. When SLBMs, or submarine-launched ballistic missiles, were being developed in the late 1950s, the U.S. Navy was opposed to their production. Naval officers feared that paying for the creation of a naval missile program would require the redistribution of funding from traditional naval programs. Furthermore, the submariners themselves disliked the idea of using submarines to launch missiles against land targets, as they were used to launching torpedoes against ships. Not until civilians took on these entrenched military interests was headway made. The Killian Committee, a civilian advisory committee to President Eisenhower, was instrumental in identifying supporters within the Navy and pushing the program forward. [36]

As the SLBM case shows, military personnel can become so specialized that they have a difficult time envisioning and accepting new tactics and strategies. Jack Snyder (1984) describes officers whose specialization leads them to "forget that other means can also be used toward the same end." Militaries tend to privilege conventional programs over nuclear weapons, not only because officers are protecting turf, but also because conventional wars are what they have always fought, and will continue to fight. Soldiers

[36] Sagan 2003, citing Harvey M. Sapolsky, 1972, *The Polaris System Development*, Cambridge: Harvard University Press.

have experience with non-nuclear weapons-based conflict; military leaders know how to calculate the risks and costs of conventional weapons-based missions.

Consider Curtis LeMay, the U.S. Air Force general who was infamous for leading the devastating firebombing of Japan during World War II and for his ruthless "Sunday punch" war plans that called for using nuclear weapons to destroy scores of cities. Yet even LeMay, despite his willingness to consider employing nuclear weapons, prioritized traditional Air Force interests above the nuclear program. As Commander in Chief of the Strategic Air Command (SAC) until 1956, LeMay placed ICBMs (intercontinental ballistic missiles) as only sixth on a list of the Air Force's highest priority weapons, below four new types of aircraft and a cruise missile program. Traditional aircraft and related weaponry (cruise missiles were used to help bombers reach their targets) had been used to fight and win wars since 1939, and LeMay professed uncertainty about the reliability and accuracy of missiles.[37]

In making this recommendation, LeMay was thinking not only in terms of the best interests of SAC, but also of the United States. At the time, ICBMs were an unproven delivery system. The first test of an Atlas missile did not come until June 1957. Those in the Air Force who were opposed to funding ICBM development must have felt vindicated when the June test, and a second test in September, failed in spectacular fashion as the missiles exploded. The Atlas missile would not be tested successfully until November 1958.[38] Thus, in 1956, LeMay was prioritizing not only based on SAC's traditional interests, but also on

[37] Neufeld 1990.
[38] U.S. Army Center of Military History, 2010. *History of Strategic and Ballistic Missile Defense* (Vol 2). Washington, D.C. : Center of Military History, U.S. Army.

the fact that aircraft promised the most reliable and dependable means of defense and attack.[39]

While there were others in the Air Force who supported the development of ICBMs, civilians, in the form of the Killian Committee and civilian Pentagon officials, once again had to intervene in order to proceed with the missile program.[40] Left to itself, without civilian oversight and involvement, the military would have opted to continue its traditional programs. In this case, civilians pushed for new technology to advance the nuclear weapons program, while military leadership was more risk-averse and preferred to allocate more resources to tried-and-true, useable delivery systems. Both groups of public servants surely believed they had the best interests of the country in mind, but they came to contradictory conclusions as to what would best serve those interests.

Building an Arsenal

The traditional interests of the military and lack of incentives to accelerate a nuclear weapons program do not, however, mean that military decision makers are uninterested in possessing nuclear weapons. On the contrary, nuclear weapons may provide several benefits to a state military. But once a state has acquired nuclear weapons, military interests are generally better served by accumulating the weapons themselves than by increasing the pace of the program.

What does accelerating a nuclear weapons program look like once a state has already acquired a nuclear bomb? A state may decide to open a second route to the bomb (i.e. plutonium in addition to uranium), or to build more sophisticated facilities and technologies to attain a goal such as the ability to produce weapons more quickly, or to

[39] I thank John Langdon for insights into this historical case.
[40] Sagan 2003.

develop much more powerful thermonuclear weapons. Military officers typically prefer to use budgetary and program resources to build a larger arsenal rather than to invest in developments that may or may not result in future capabilities. When considering the cost and timelines involved with accelerating a nuclear weapons program, militaries are more likely to prefer stockpiling the weapons the program is currently able to produce.

Recall the distinction between nuclear program and nuclear posture. Posture decisions concern the arrangement and use of the nuclear weapons themselves, and may be implemented quickly, within hours or days. Mobilizing pilots to sit inside fueled bombers loaded with nuclear warheads, waiting for orders, is a posture decision. Program decisions involve long-term plans about nuclear weapons development that require substantial state resources, and may be implemented over a period of years. A decision to begin a crash program to produce a hydrogen bomb, or to begin an indigenous uranium enrichment program, or to work with a foreign country to build a new reprocessing plant to supply plutonium for nuclear warheads, is a program decision.

Acquiring nuclear weapons increases the prestige of the military. Secretly accelerating the pace of a nuclear weapons program does not confer status on a military; a nuclear arsenal does. Furthermore, possessing nuclear weapons may permit the military to pursue other interests and to fight conventional wars. A state may become emboldened to engage in conflict abroad, relying on nuclear weapons to provide a deterrent force capable of preventing reprisals against the homeland.

Barry Posen argues that militaries want to "retain the initiative, incorporate nuclear weapons into their array of warfighting doctrines, and develop organizational missions

that ensure survivability and growth of the armed forces."[41] Professional militaries are concerned with securing the state, but also with their own institutional goals. Possessing nuclear weapons can both promote state security and expand the role of the armed forces. But the survivability and growth of the military is not best served by allocating large portions of a finite set of resources to a cutting-edge nuclear weapons program. Building a nuclear arsenal, however, quickly and concretely leads to growth within the military, as the need for more personnel and facilities expands. And an arsenal that can deter an attack thus ensures the military's survivability.

The military's preference for building an arsenal rather than advancing a program is illustrated by the Australia case. The Australian military was involved only in attempting to procure weapons and in building delivery systems. The officers lobbied for the procurement (from a third party) of nuclear weapons, with the Air Force submitting the recommendation to the civilian government. Each time efforts lagged, the military would work to get procurement plans back on track.[42] The grander ambitions that led to an attempt at an indigenous *program*, however, were centered in the civilian bureaucracy with the Australian Atomic Energy Commission (AAEC)[43] and supported by civilian leaders at the cabinet level.[44] The Australian military viewed the acquisition of a nuclear arsenal as providing capabilities in the short term, whereas pursuing a nuclear weapons program would be slow and the outcome would be uncertain.

Soldiers are more likely to think about other states' capabilities, not about the intentions of those states' leaders. Military officers tend to place trust in hard numbers of

[41] Posen 1986.
[42] Walsh 1997.
[43] Ibid.
[44] This is based on parliamentary debate transcripts from 1949, which I accessed via parlinfo.aph.gov.au.

troops, weapons, transports, and equipment. The intentions of those with the power to use such capabilities, however, are uncertain and unpredictable.[45] It stands to reason that militaries also think mainly about capabilities, and not about their government's intentions, when thinking about their own arsenals. Using scarce resources to amass an arsenal is preferable to investing heavily in development that may or may not result in better weaponry.[46]

Military biases shaped the decision making process for China's nuclear weapons program. China's crash program culminated in a successful nuclear test in 1964. Afterwards, the nuclear program progressed slowly, despite border clashes with Russia in the late 1960s, and nuclear threats from the Russian government. Chinese military officers pushed for a larger arsenal.[47] Rather than allocating funding to improve upon existing land-based missiles, officers advocated for amassing more of the nuclear weaponry they already had: what was known, reliable. Civilian authorities had to intervene at high levels in order to bring about operational innovation. [48] But in an institutional setting where civilian control over the military is relatively weak, civilian authorities do not have the ability to effect change quickly when the military is opposed. Such a civilian-driven policy change would likely be resisted, and the implementation prolonged.

Inward Focus

[45] Huntington 1957, 66.
[46] There are certainly segments of state militaries that have strong institutional interests in pursuing experimental research and development projects, even after it has become clear that success is unlikely. Outlandish and costly weapons development programs are often widely and scornfully publicized. Overall, however, a military's interests regarding *nuclear* weapons revolve around the acquisition of weapons rather than the long-term course of a nuclear weapons program.
[47] Sagan 1993, 15.
[48] Ibid.

Military organizations in weak civilian or military regimes can be inward-looking: concerned more with domestic stability and internal politics than with external security threats. Defense policy may be designed with the protection of the regime prioritized over the protection of the nation's security. Militaries with this inward focus do not have great incentive to accelerate nuclear programs, as they primarily need soldiers, tanks, and guns to provide domestic stability. Nuclear weapons, in this scenario, cannot help the military achieve its primary goal.

A weak civilian government fearful of a military coup will take measures to secure the regime. This strategy, called coup-proofing, bolsters the regime's power at the expense of some of the institutional features needed for a military to operate effectively. Officers may be promoted and placed in leadership positions based not on merit, but on personal loyalty to the ruling elite. In China, the Central Military Commission of the Communist Party manages the entirety of China's conventional forces, from the strategic goals and institutional structure of the PLA all the way down to missions and tactics. Chaired by the General Secretary of the Communist Party, the CMC promotes military leadership based largely on party loyalty, wielding the PLA as an arm of the party.[49]

Military leadership may also be shuffled or rotated, so that no one general gains too much power. In one extreme case of coup-proofing measures, Saddam Hussein was known to reward Iraqi generals who had been triumphant in battle by executing them before they could become national heroes with personal political power.[50] A military that has been subjected to coup-proofing by a weak civilian government has thus been designed to be inward-looking, focused on defense of the regime more than on defense of the country.

[49] Allen 2002.
[50] Belkin and Schofer 2003.

A military government must be inward-looking in order to survive, and its resources are used accordingly. Military juntas require soldiers, armaments, and vehicles to maintain order and conduct political repression. Nuclear weapons are of no use in pursuing the daily work of protecting the regime. Military leaders who fear a coup may also use interstate conflict to strengthen their power at home by attempting to create a rally-round-the-flag effect.[51] The Falklands War, fought between Argentina and the United Kingdom in the summer of 1982, is one example. The military government of Argentina, led by General Leopoldo Galtieri, ordered an (ultimately unsuccessful) invasion of the disputed Falkland Islands. Galtieri planned to shore up the military regime amidst faltering public support, and, concerned about a possible transition to democracy, to secure the military's position and protect it from future reprisals.[52] By regaining the islands, Galtieri hoped to turn a national triumph into a political victory at the polls.[53] The general's regime could not use the nuclear weapons program to earn popular adulation; a decision to speed up weapons development would not translate into public support for the regime. The military's policies stemmed from their focus on survivability. Inward-focused militaries, as a matter of practicality, are unlikely to expend the resources to accelerate a nuclear weapons program.

Minimizing Civilian Participation

Militaries desire autonomy from civilian oversight so that they can better pursue their preferences. Information asymmetries regarding military operations and capabilities leave civilians at a disadvantage even in governments that maintain strong civilian control

[51] Huth and Russett 1993.
[52] Levy and Vakili 1992.
[53] Ibid.

over the military.[54] In the U.S. case of relatively strong civilian control, the military was still able to purposely withhold information on nuclear command and control from President Kennedy. A powerful civilian committee, the Joint Committee on Atomic Energy, had to intervene in order to obtain that information for the president.[55] Militaries in states with weak or no civilian control can press their advantage further than can militaries in states with strong control, taking more significant steps to limit the influence of civilian leaders in decision making.

One can observe this occurring in countries that fall across the spectrum of civil-military relations. The Australian defense establishment's plans to procure nuclear weapons from Great Britain were continually thwarted by civilian political leaders, so the Ministry of Defence intentionally shifted the focus of its efforts to delivery systems, which the cabinet was less able to control.[56] In the United States, during the mid-1950s, the Strategic Air Command (SAC) maintained outdated war plans calling for sending nuclear-armed SAC bombers to overseas bases near the USSR. The bases were highly vulnerable, and civilian analysts at RAND tried to convince SAC leaders that the plans should be revised. But the desire for autonomy won out over strategic logic. Fearing that acquiescing in civilian recommendations would set a precedent, allowing more civilian interference in the future, SAC refused to change the plans. RAND had to circumvent SAC, briefing senior Air Force officials directly, for the plans to be changed.[57]

Both of these instances of militaries attempting to limit civilian participation in security affairs occurred in states with relatively strong civilian control of the military. The

[54] See Posen 1984.
[55] Feaver 1992.
[56] Walsh 1997.
[57] Sagan 1994 (14).

ability of the military to isolate civilians from decision making is more pronounced in states with weaker civilian control. Pakistan's military has enjoyed high institutional capacity since the country's independence, peaking during periods of military rule, while the capacity of democratic institutions, and specifically civilian control over the military, has remained low.[58] During Benazir Bhutto's tenure as Prime Minister, beginning in 1988 after the death of the head of state, General Muhammad Zia-ul-Haq, the military suppressed information about the nuclear program, keeping Bhutto in the dark. As Bhutto's Pakistan Peoples Party had won a plurality, not a majority, of seats in parliament, the party had needed to ally with smaller groups to form a coalition government. Bhutto had agreed to the army's demand for authority over nuclear policy.[59]

Under this arrangement, the Pakistani military established a very high level of autonomy over nuclear affairs. Strikingly, shortly after becoming Prime Minister, Bhutto visited Joint Staff headquarters and was refused a briefing on the nuclear program by her Chief of Army Staff (who later also refused to brief Bhutto's successor).[60] The United States at the time described Bhutto as being "unlikely to gain control over nuclear decision-making anytime soon."[61] As executive of a weak civilian government, Bhutto was simply unable to access the information and authority from the military that she needed to have real influence over nuclear policy.

Protecting the Arsenal

Typically, nuclear weapons are regarded as means by which to protect a state. But if the nuclear weapons themselves are considered to be objects of high value, then they

[58] Spector 1990.
[59] John 2005.
[60] Ibid.
[61] CIA Near East and South Asia Review from May 5, 1989.

become objects *to be protected*. A military will tend to be less interested in developing or modernizing a nuclear weapons program, and would prefer to use scarce resources on first producing the physical arsenal, and then protecting it.

Scott D. Sagan writes that militaries have a "common organizational tendency to place excessive value on means rather than the ends of national policy."[62] Sagan uses the term "excessive," but this attitude is logical: without weapons, a military cannot attack, defend, or deter. The means are what enable armed forces to carry out their essential functions.

Excessive devotion to weaponry, however, takes this logic to the extreme. Sagan has compiled a telling series of speeches made by former Pakistani president General Pervez Musharraf, in which the general refers to Pakistan's nuclear weapons as "strategic assets." As symbols of Pakistan's security, identity, and technological prowess, nuclear weapons are more than components of an arsenal. Their very existence and survival are considered to be vital to national security. From a 2001 speech by Musharraf: "Pakistan's armed forces and every Pakistani citizen is ready to offer any sacrifice in order to defend Pakistan and secure its strategic assets [nuclear weapons]."[63] This is a remarkable statement. The nuclear weapons themselves are viewed as vital assets that the military, and even the Pakistani people, are charged with protecting. In a 2004 speech, again by Musharraf, the nuclear program is referred to as one of two "national vital interests," the second being the disputed border area of Kashmir.[64] Just as Pakistan guards and lays claim to the land

[62] Sagan 2009, 238.
[63] Pervez Musharraf, "Address to People of Pakistan," *Presidential Speeches*, Sept 19, 2001, quoted in Sagan 2009, 238.
[64] Sagan 2009, 238.

comprising Kashmir and the people living there, it guards its nuclear weapons as similarly valuable physical holdings worthy of being defended.

Pakistan decided to accelerate its nuclear program in 2009. This was not due to increased security threats to the state, but because of a new threat to the nuclear weapons program itself. In April of that year, U.S. President Barack Obama delivered what became known as the Prague speech, in which he pledged to restart work toward a fissile material cut-off treaty. If such an effort were to be successful, there would be new restrictions on fissile material production. Pakistan responded by accelerating its uranium enrichment program and the construction of reactors to be used for producing weapons-grade plutonium.[65] Increasing production would allow Pakistan to stockpile fissile material in anticipation of a future international prohibition.[66]

In a state with weak or no civilian control of the military, where nuclear weapons are more likely to be highly valued as a national interest, the weapons are protected. There is one sure way to deplete a nuclear arsenal: to use the nuclear weapons. The state that uses its nuclear weapons doesn't have them anymore, and, unlike a machine gun or a grenade, more cannot immediately be produced. This brings us to the final reason why more militarized states are less likely to decide to accelerate the development of nuclear weapons: militaries are more likely than civilians to view nuclear weapons as unusable.

The Unusable Arsenal

Nuclear weapons began as warfighting tools and were used in war twice, in the bombings of Hiroshima and Nagasaki. Since 1945, nuclear weapons have never been used

[65] Uranium and plutonium production plans reported in *The New York Times* by Thom Shanker and David E. Sanger, "Pakistan is Rapidly Adding Nuclear Arms, U.S. Says," May 17, 2009.
[66] That Pakistan's acceleration was a response to the Prague speech was articulated by Ashley Tellis in an interview reported by Praveen Swami in *The Telegraph* on October 10, 2010.

in combat. Yet nuclear weapons-seeking states have spent enormous amounts of time, money, and material and human resources in developing their own nuclear programs. If nuclear weapons will not be used, why should a government ever decide to accelerate or expand a nuclear weapons program once the first set of bombs has been constructed? Why improve an unusable weapon?

First, the organizations that build, research, and maintain nuclear weapons have their own parochial interests. In most states, those who have something to gain from nuclear weapons production and maintenance include both civilian and military personnel. These stakeholders pursue their interests by lobbying for advances in nuclear weaponry or pushing for larger arsenals. When the conditions are right, they can be influential.[67]

Second, the fear that an adversary may actually use its nuclear weapons persists. The logic of nuclear warfare leads to the conclusion that no state will use nuclear weapons against another because the reprisals would be catastrophic. Just the uncertainty over whether the attacked state (or a third party) might have the capability and will to then carry out nuclear retaliation should be enough to dissuade the potential attacker.[68] Yet can one truly be certain that this logic will hold? Many heads of state have not been willing to bet the survival of their countries on the belief that other governments will act according to the strategic logic of nuclear war. That nagging fear may seem to defy logic, but when the cost of nuclear war is so extraordinarily high, even a minimal risk of the event is enough to affect decision making.

[67] The ability of nuclear agencies to influence the course of nuclear weapons programs will be addressed in detail in Chapter 4.
[68] Waltz 2003.

While the possibility of nuclear attack will never be entirely eliminated unless the weapons themselves are eradicated, military leaders must weigh the likelihood of such an event as they plan for future conflicts. In allocating resources for the armed forces, the decisions officers make will determine what weaponry and equipment will or will not be available to use in the next conflict abroad, or in the defense of the country. Military leaders may desire a nuclear arsenal, which serves as a deterrent, and which may free the military to pursue expansionist goals conventionally, believing the homeland to be secure. But because nuclear weapons will not be used in war, resources should not be diverted away from useful conventional weapons in favor of advancing a nuclear weapons program.

Militaries prefer certainty. The offensive use of nuclear weapons multiplies uncertainties. Nobody knows what a nuclear battlefield would look like, or what would happen after the first city was destroyed.[69] Planning for a nuclear war is an exercise of the imagination. Officers know that, when it comes to ensuring military readiness, they need soldiers, conventional weapons, and equipment to make up their fighting force.

Civilians are more likely to decide to accelerate nuclear weapons programs and may see a greater potential to use nuclear weapons. The mystique of these powerful, near-apocalyptic weapons in the popular imagination is more powerful when one is more removed from the details. But to military strategists and tacticians, the practicalities of waging war seem incompatible with nuclear weaponry. General LeMay, as SAC commander in chief, came to call nuclear missiles "political and psychological weapons," impossible to use, but so frightening as to be able to compel an adversary to accede to

[69] Waltz 2003.

political demands.[70] Indian Chief of Army Staff General Padmanabhan said: "I do not see the weapon as a war-fighting one . . . the nuclear weapon is also to keep in the basement."[71] Military leaders are more likely to view nuclear weapons as political objects, not as usable weapons of war.

Finally, recall that offensive-mindedness, while in the best interests of the military as an organization, is also often in the best interests of the state; as stated earlier, wars are not won defensively. Military personnel acting to secure the state should be inclined to pursue weapons systems that can be used offensively. Nuclear weapons cannot.

Testing the Theory

I test this theory using two approaches: statistical modeling, and case studies. The case studies appear in Chapter 5 and provide historical context supporting the idea that weak civilian and military governments are less likely to decide to accelerate nuclear weapons programs. The statistical model uses a new and original data set that I created by examining government documents and nuclear program histories. I compiled a complete list of all political decisions to accelerate, decelerate, or stop a nuclear weapons program that occurred in each country that has ever started such a program. Since nuclear weapons programs are highly secretive, I cannot be certain that I have identified every decision, especially in cases of governments that operate under extreme secrecy and allow very little information to become public.[72] But even with the constraints that accompany any research on sensitive, national security-related topics, this list has been thoroughly and

[70] Neufeld 1990.
[71] Narang 2014, 79.
[72] The programs of North Korea and Israel are probably the most challenging for researchers. Very little information is publicly available in either of these cases.

painstakingly constructed and represents the best information we have on nuclear programs at the present time. The case studies that appear in Chapter 5 provide support and deeper context for the results obtained from the statistical model.

I use an event history model to examine the risk that a government will decide to accelerate its nuclear weapons program. Only states that have already decided to begin a nuclear weapons program (see Chapter 2) are included in this analysis. In any given calendar year, a state is at risk of deciding to accelerate its program. When that decision is made, it is recorded in the data set. Then, in subsequent years, the state is again at risk of making another decision to accelerate. States remain at risk until the data set is truncated, in 2011. The event history model takes this artificial end point of 2011 into account, so that it does not affect the analysis. More details on this model can be found in Appendix 3.

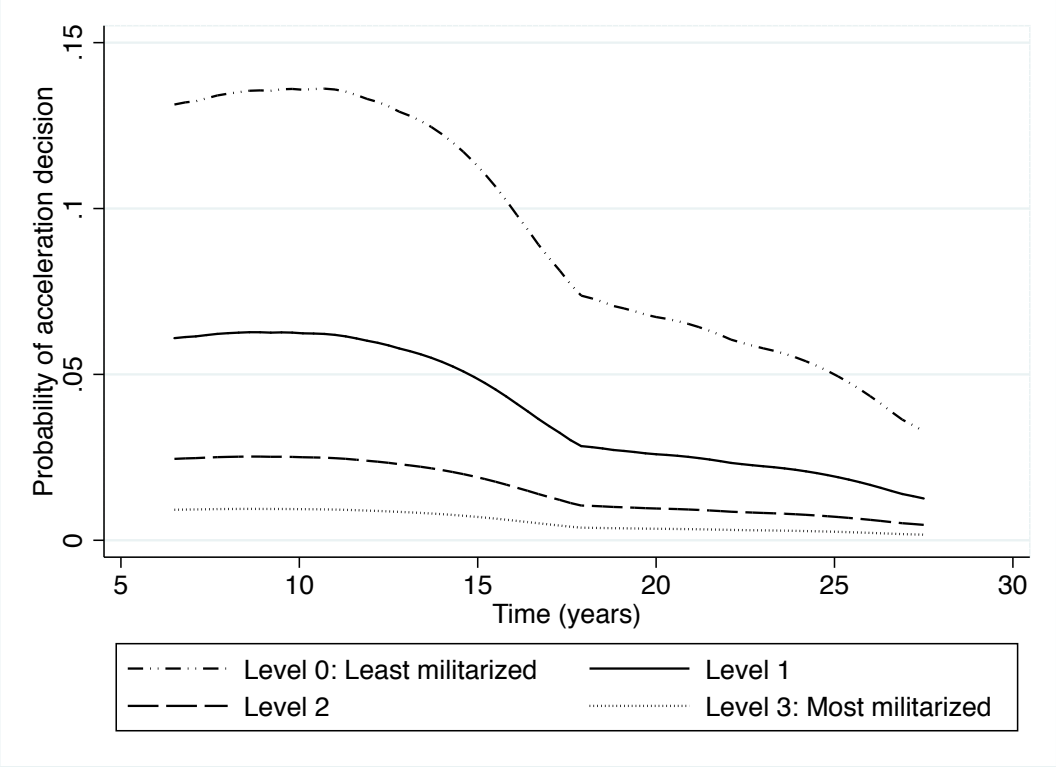
In order to measure how militarized each state's government is in each year, I again use the index compiled by Jessica Weeks (2012). In her study of whether different types of governments are more or less likely to enter into armed conflict, Weeks measures a "military dimension" as one of two components she uses to categorize states into different types of authoritarian regimes. Not only structural, institutional characteristics, but also the personal experience of the head of state, are measured.

The military dimension index serves as a measure of civilian control over the military. For example, a state with a military leader, in which the cabinet is populated with military officers and the military high command is involved with politics, has little civilian control over the military. The higher the index is, the weaker civilian control over the military is.

A close look at the data reveals that some states' civil-military relations change over time, while others stay fairly static. Overall, neither a state's level of democracy nor whether a state is a "Western industrialized" state correlates strongly with civilian control. Civilian control is not only found in highly democratic countries. Governments with civil-military relations that fall on the "strong civilian control" end of the spectrum exist across the range of democratic to autocratic regimes.

As expected, the model indicates that the less civilian control of the military there is, the less likely a state is to choose to accelerate its nuclear weapons program.

Figure 3.1 Hazard rate of decision to accelerate nuclear weapons program by level of militarization of the government



Recall from Chapter 2 that the hazard rate measures the likelihood that the event modeled will occur in a given year, conditional on its not yet having occurred at that time. In Figure 3.1, I compare the hazard rate of the decision to accelerate a nuclear weapons program

when a state has strong civilian control of the military (level 0), to less strong civilian control (level 1), to weak civilian control (level 2), to military government and a lack of civilian control (level 3). Observe that the difference between weak civilian control and military government is relatively minor. But the difference between strong civilian control and weak civilian or military control is much greater. At the height of the curve, there is a 15% probability of a decision to accelerate when militaries are governed by strong civilian control, and only a 0-3% probability of a decision when civilian control is weak or absent. The risk of a decision to accelerate is highest, and changes relatively little, during the first ten years after the last decision to start or accelerate a nuclear weapons program.

Conclusion

Militaries have an organizational tendency to privilege conventional programs over nuclear programs. This happens because of organizational preferences that may either support or conflict with sound strategy and decision making. While military officers may provide security rationales to justify their decisions, and may believe that their decisions are indeed in the best interests of the country's security, policies can be shaped by motives that stem from the military's preferences instead of from its mission to secure the state.

States with weak or no civilian control of the military are less likely to decide to accelerate the development of nuclear weapons. Militaries have traditional interests, work to build arsenals, are inwardly focused, strive to minimize civilian interference in military affairs, desire prestige, and believe that nuclear weapons are unusable. The more influence the military has over state decision-making, the lower the risk of acceleration will be.

The military's organizational tendency to privilege conventional programs over nuclear programs may change over time as nuclear interests become more entrenched within the military. On the other hand, over time, militaries may come to perceive nuclear weapons – their unusable arsenals – as obsolete. In April 2013, the U.S. Air Force removed seventeen officers from ICBM launch duty for violating missile safety rules or failing to report violations committed by fellow officers. An internal Air Force email describes "rot in the crew force," a "culture of indifference," questioning of orders, failure to properly respect superiors, and other indications of the loss of discipline and morale.[73] Launch crews, relegated to lonely posts where they wait, believing they will never use the nuclear missiles they have been tasked with, are marginalized. They are isolated from the rest of the armed forces, and are demoralized by the notion that they are just "baby-sitters" for outdated and irrelevant weaponry.[74]

This feeling among fairly low-level military personnel that nuclear weapons are obsolete may be more likely to occur in the original nuclear weapons powers. Soldiers serving in more recent nuclear weapons states might continue to view nuclear weapons as essential, particularly in states with a nuclear strategic rival. But the attitudes of the U.S. Air Force officers indicate that beliefs about nuclear weapons do change. The event history model shows that the hazard rate declines with time, meaning that for all types of governments, the likelihood of accelerating a nuclear weapons program gradually decreases.

[73] "Air Force Officers Stripped of Power to Launch Intercontinental Nuclear Missiles," CBS News, May 8, 2013; and Robert Burns, "Air Force Faces a Cascade of Missteps," Associated Press, October 12, 2013.
[74] Bruce Blair, co-founder of Global Zero and former 1970s Air Force ICBM launch control officer

Finally, governments with weak civilian control of the military, while less likely to decide to engage in nuclear weapons development or program expansion, are not necessarily better stewards of nuclear weapons. For example, military governments prioritize readiness for war fighting over securing and safeguarding nuclear weapons, raising the risk of an accident.[75] From a broader standpoint, military governments typically wield the sharp tools of political repression and violence with their domestic populations. That militaries are more interested in conventional than nuclear arms does not mean that a military regime should in any way be preferred to civilian rule.

Civil-military relations are one of the factors affecting a state's risk of accelerating its nuclear weapons program. Another domestic institution also impacts this risk. Each state with a nuclear weapons program has built a nuclear bureaucracy to support and direct it. Some nuclear agencies have a great deal of autonomy to pursue their own preferences, while others are constrained. In Chapter 4, I explain the role of the nuclear agency, and the importance of its institutional structure, in decision making.

[75] Sagan 1996.

CHAPTER 4

The Path and Pace of Nuclear Weapons Programs:

Nuclear Bureaucracy

What role does the nuclear bureaucracy play in executive decision-making? Heads of state set the course of nuclear weapons programs, but they may be influenced to different degrees by the state's nuclear agency. What determines how influential a nuclear agency can be? And why do nuclear agencies have the potential to be more influential regarding nuclear weapons programs than other national security or defense agencies?

The answers hinge on the exceptional nature of the subject of nuclear weapons themselves. It has been difficult for scholars to develop complete political histories of nuclear weapons because of the intense secrecy surrounding proliferation programs. Not only that, the science behind nuclear weapons design and production is extremely sophisticated, and the technology required to produce weapons-grade material is difficult to explain to a layperson. Finally, there is a common tendency among nuclear weapons outsiders to be awed by the devastating power of these weapons and the notion of atomic and sub-atomic reactions, which can seem mystical even to scientists. The technical, secretive, and mystical nature of the very topic of nuclear weapons greatly limits understanding, and thus limits the power of the people who usually control decision

making: heads of state, parliamentarians, and Cabinet-level civil servants. Power lies more heavily in the hands of the nuclear agencies, which provide information to those politicians about the nuclear weapons programs.

Nuclear weapons not only command the attention and interest of many in government, they also may intimidate and alienate those who govern. Members of national parliaments have made comments indicating their fascination with, but complete ignorance of, nuclear weapons. Great trust is placed in those who run nuclear programs and seem to have a command of the information. Those agents have a greater ability to shape the information that political actors receive because it is so difficult for outsiders to lift the curtain and interpret what they see behind it. As a result, decision making regarding nuclear weapons programs can be shaped by domestic nuclear agencies that exert high levels of influence on the executive.

Nuclear agencies that have high levels of influence tend to share common characteristics. Agencies can be designed in different ways by their creators, and sometimes, by the bureaucrats who inhabit them. When nuclear agencies are designed to be independent of government control and are given direct access to the head of state, they are able to exert greater influence over decision making. The key characteristics determining high influence include having the ear of the head of state, having independence from the cabinet or other executive bureaucratic apparatus, experiencing limited state oversight, and receiving legal codification of some or all of these institutional features.

Nuclear Bureaucracy

The security environment in which a state perceives itself to be shapes state military interests, political interests, and economic interests. That environment is analyzed and interpreted by people working within institutions that may have competing interests and opinions. Across state agencies, not every actor will possess the same information or embrace the same set of priorities. And not every agency will have equal ability to make decisions or shape policy. States embarking upon a militarized nuclear program do so within this environment of varying institutional interests and power.

While security concerns are an obvious factor in a state's decision to pursue any kind of weapons development, external threats have not been sufficient to explain the nuclear proliferation processes that states have undergone. Some states have begun nuclear weapons development but have later slowed or ended the programs. India's program slowed significantly in the mid- to late-1970s despite nuclear progress in its regional rivals, China and Pakistan. Argentina and Brazil gave up their pursuit of nuclear weapons despite little to no change in their security environments.

External threats to a state's security can indeed have an effect on decision making, but any unique impact they may have has been exaggerated. One can often find a security event that preceded a decision by weeks, months, or years, and use that event to explain the decision. However, identifying an event does not explain the mechanisms at work within the government that made the decision. While events can and do influence decision making, a state's domestic institutions may interpret and utilize events in competing ways. More powerful and persuasive agencies should have greater success in obtaining favorable decisions.

How decisions are made, and who has the authority to make or shape them, are the primary factors used to assess power in policymaking. A casual glance at nuclear weapons decision making typically leads most to assume that policy making is highly personalized. This characterization may be true in some cases, and a change in leadership, especially in regimes with long-standing leaders, can have significant effects on nuclear policy. However, attributing decision making to unique personal traits of individual leaders is not only theoretically unsatisfying in a systemic analysis of state behavior, but also ignores the differing institutional structures of state nuclear weapons efforts that impact a leader's decision making.

Heads of state obtain information on their nuclear weapons programs from several different state organizations and agencies. These groups all have opportunities to shape the executive's understanding of weaponry, strategy, and security. In some cases, executives receive a broad sampling of information and viewpoints, while in others, executives receive narrow, pre-determined sets of policy proposals. The structure of the nuclear bureaucracy affects the ability its bureaucrats will have to control the information being provided to the decision maker. Nuclear bureaucracies change over time, and thus the role that a particular nuclear agency plays in informing and persuading the head of state may also change.

While research has been done that describes nuclear bureaucracy, scholars have not yet studied the impact that different types of institutions have on the direction that nuclear weapons programs take. In 1992, Peter Feaver wrote:

> "The resolution of this question [how bureaucratic politics affects nuclear behavior] is made more vexing by the difficulty of formulating the role bureaucratic factors play in terms of testable hypotheses. . . We know that bureaucratic conflict changes nuclear behavior, but the precise causal relationship is ambiguous. . . Perhaps better information about the role of bureaucratic politics

in nuclear countries will suggest more testable hypotheses."[1]

Twenty years later, we do have more information about bureaucratic politics in nuclear countries. Using it to uncover the "precise causal relationship" of bureaucratic influences to state behavior is the challenge undertaken in this project.

Executive Decision-making

The authority to make nuclear weapons policy is, without exception, concentrated in the executive. Those policy decisions are not made in a vacuum, however. Executive preference may be made up of many different components, not all of which are unique to the individual. We should not assume away the role that other branches of government – the legislature, the bureaucracy – have in informing the executive, pressuring the executive, and sending signals. All of these activities may shape the executive's preferences.

While I do not use a principal-agent model in this chapter, my theory of nuclear bureaucracies is rooted in concepts articulated by principal-agent theory. In principal-agent theory, first developed in economics and later applied by political scientists, "principals" are those in positions of authority, and "agents" are those who act on behalf of their principal(s). Think of heads of state as the principals and nuclear agencies as the agents. On the most basic level, the head of state has the power to determine the path of a nuclear weapons program, and to approve or deny a nuclear agency's request. The nuclear agency executes the head of state's decision. But that simplistic understanding of nuclear program policy overlooks the complexities of the principal-agent relationship. Agents do not only carry out orders. They also provide information and make policy proposals to the

[1] In Guarding the Guardians, 173.

principal, influencing the principal's beliefs about nuclear weapons programs. Thus, influential nuclear agencies have the potential to affect policy choices.[2]

The ability of a nuclear agency to influence the head of state varies. Some heads of state are personally invested in the nuclear weapons program. Zulfikar Bhutto in Pakistan, David Ben-Gurion in Israel, Charles de Gaulle in France, and Jawaharlal Nehru in India were all heads of state who were highly personally involved in directing their state's nascent nuclear programs.[3] These cases are well-known and particularly interesting because of the executive's personal stake, but it is more common for the executive to delegate management of the details of a program to others. As a nuclear program ages, new heads of state take office and inherit an ongoing effort with its own history and momentum. Most state leaders are also not familiar with nuclear science and technology, and most, at the beginning of their time in office, are not well-versed in nuclear secrets, either. They depend on their nuclear agencies for advice and information. And even those now-historical figures who were personally invested in their programs still came to rely on their head scientists' reports for information about the progress of the nuclear weapons efforts.[4]

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[2] There is widespread support for the idea that bureaucracies can influence policy decisions. Allison (1971) observes in his classic study of American foreign policy bureaucracy during the Cuban Missile Crisis that the bureaucrat wields power by deciding which information his or her boss will receive. McCubbins, Noll, and Weingast (1989), using the American case, look at how agencies set the status quo by identifying what policies are most likely to pass or be approved, and then proposing their preferred policy from among that set of identified winners. Shipan (2004) constructs a spatial model, which he empirically tests, to demonstrate how a U.S. federal agency is able to act autonomously under certain conditions. Krause (1996) finds that, in the American political system, principals influence agents, but agents also influence principals via preference-shaping signals.

[3] Although Nehru never made the formal decision to begin a militarized nuclear program, he worked closely and on a personal level with Dr. Homi Bhabha, the head of India's civilian and later weaponized nuclear programs, to ensure India developed the means to be able to pursue nuclear weapons.

[4] Halperin (2006), in examining foreign policy making in the United States, argues that officials who have special relationships with the president will be more likely to influence the president on policy decisions. The president may feel that he should defer to such a member of the bureaucracy when it comes to policy in his or her area of expertise. Indeed, a president can come to feel that he owes that person his support and should not disagree with their policy recommendations.

There is an important distinction between this type of decision – a decision to accelerate an ongoing nuclear weapons program – and the decision to start such a program in the first place. While the decision to pursue nuclear weapons is typically made and initially driven by a handful of people, after the program begins, a greater number of people gain the ability to shape decision making.[5] Consider the case of the United Kingdom, one of the first countries to begin a nuclear weapons program. In these earliest days of the military applications of nuclear science, governments simply did not yet know how to structure these programs to handle their scope and scale. At the outset of the nuclear weapons program and for the first few years, outside of the actual program staff, only the prime minister and about half a dozen to a dozen others at the ministerial level knew that Britain was pursuing the bomb. Within five and a half years of the decision to start a program, the Atomic Energy Committee was established and parliament was informed.[6] As programs grow, they can no longer be led by a handful of ministers in a back room, and the number of people and organizations who can influence the course of the program increases.

Nuclear agencies may be able, to varying degrees, to control the information flow to the executive. In Australia, the nuclear agency (the AAEC) purposely "glossed over" problems and emphasized successes when publishing its reports for the government.[7] Shaping the message that politicians receive to reflect organizational interests is common practice across nuclear agencies. While heads of state typically come to understand that the information they receive from the bureaucracy is not entirely objective, in the case of

[5] Born et al 2010, 229.
[6] Norris et al, 1994.
[7] Moyal 1975, 371.

nuclear weapons programs, the agency's control persists due to the secret and highly technical nature of the information. It is especially difficult for the executive to determine what he or she may not have been told and whether that missing information is meaningful.

The information flow to the executive is also affected by the agency's level of autonomy within the government. A more politically independent agency that is less dependent on the support of elected officials for its existence and operations should affect nuclear policy differently in two main ways. A more autonomous nuclear agency is more likely to be able to set nuclear policy from the bottom up, according to its own agendas and practices. And the more independent the nuclear agency is from political control, the more freedom the agency has to try to persuade decision makers to follow the agency's preferred policies.

The relationship between the executive and the nuclear bureaucracy is thus not just hierarchical. Influence is not unidirectional. Institutional structures constrain or free an agency to have some level of influence over an executive. I first discuss the organizational preferences nuclear agencies develop, and then identify which structural features determine agency influence and ability to shape executives' preferences.

Nuclear Agency Preferences

I assume that a nuclear agency's preferences are largely driven by institutional self-interest. Bureaucrats and scientists working for a nuclear agency will desire more funding, the advancement of scientific knowledge, more staff with which to conduct research and execute development, and better facilities and equipment. The staff of a nuclear agency

will, above all, prioritize the continuation of the nuclear program upon which their organization and livelihoods are predicated. Continuation depends on the nuclear weapons program's importance and relevance; to exist as more than just a maintenance organization tending to existing nuclear weapons, a program must always be moving forward: pursuing the next breakthrough, developing the next weapons system, working on the next type of nuclear reaction.

Case histories bear this assumption out. Heads of nuclear agencies are typically champions of nuclear weapons programs. While a significant number of nuclear scientists are opposed to the growth of nuclear weapons programs, the bureaucrats and scientists who work for nuclear weapons agencies self-select into those positions. In other words, nuclear agencies are composed of individuals who believe in the mission of the agency and want to aid in the development of nuclear weapons.[8]

Nuclear scientists, who typically populate high-level decision making positions within a nuclear agency, are part of a broader scientific community. This community has its own goals and interests, such as the desire to conduct advanced work that may garner the recognition of their peers. Scientists interested in perfecting a sophisticated technology will require expensive resources like laboratories, equipment, and staff to conduct their cutting-edge work. They may also argue for more funding in order to keep scientists in the country and prevent a "brain drain."[9]

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[8] T. V. Paul (2009) writes of the U.S. scientists in the 1940s and 1950s as a mixed lot. The national laboratories were filled with atomic scientists, as they were then called, working to develop more and more deadly nuclear weapons. Those who were alarmed by the actual and potential military uses of their work left their positions and publicly spoke out on the catastrophic dangers of nuclear weapons. They chose to no longer be a part of the U.S. nuclear program.

[9] Flank 1993, 270-272.

In South Africa, nuclear scientists had a common set of goals and even a shared identity of sorts. Their research facilities, the nuclear agency's headquarters, and the main research university were all located in the same geographic area. The scientists, who sometimes announced progress in nuclear science before political leaders could, desired success and prestige. One sign of this was their work to develop a unique enrichment process and not to replicate other scientists' work from outside the country. The South African physicists did this not because the others' work was flawed, but because conducting original work was an important part of maintaining their reputations as good scientists. [10]

Scientists and civil servants who come to doubt the mission to produce nuclear weapons do not often try to change the nuclear agency from within, but usually leave the nuclear agency. Even in Stalinist Russia, where dissent could be fatal, scientists who were morally opposed to nuclear weapons could not speak out openly but could refuse to work on the project.[11] If scientists opposed to nuclear weapons remain in the relevant bureaucracy, they may be marginalized or even forced out. In India, prominent nuclear scientist Dr. Meghnad Saha disagreed with how the head of the program was proceeding with research and development. When he spoke out, the Indian nuclear agency (AEC) worked to successfully marginalize him. This marginalization was persistent and occurred even in minor ways: For instance, when Saha attended a conference held by the AEC to present his dissenting ideas, he was not given an opportunity to speak until the final day, limiting the discussion of his proposals.[12] In Russia, Dr. Peter Kapitsa was placed on the

[10] *Ibid,* 278-280.
[11] Holloway 1994, 205.
[12] Abraham 1998, 72-76.

powerful Special Committee, which reported directly to Stalin on the nuclear weapons program. He clashed with fellow committee appointee L. P. Beria, the head of police and espionage and one of Stalin's most formidable and trusted advisors. Eventually, he asked to resign from the committee, and was dismissed from his job as head of the Institute of Physical Problems a few months later.[13]

In France, High Commissioner for Atomic Energy Frédéric Joliot-Curie, a devoted communist personally opposed to war, particularly against the Soviet Union, refused to conduct scientific research toward the development of nuclear weapons. He was removed from his post in 1950. In 1951, two commissioners on the Comissariat à l'Energie Atomique (Atomic Energy Commission, or CEA), reorganized the institution so that scientific authority became subordinate to administrative authority.[14] While this event occurred prior to the official French decision to pursue nuclear weapons, it illustrates how institutions can be shaped and preferences reinforced. While dissenting opinions can be expected to exist within any organization, and not all members of an agency share the same preferences, agency preferences are consolidated when those with strong dissenting opinions leave.

Scientific/bureaucratic and political interests are interrelated. Scientists and political leaders may share the same goals regarding nuclear weapons, and they may assist each other in achieving those goals. In other cases, scientists and political leaders are at odds with each other. In either case, the nuclear agency and the executive interact with each other on matters of nuclear program policy making. Information and policy proposals

[13] "Kapitsa on Beria," sidebar by Linda Rothstein, p. 27 of the May 1993 issue of *Bulletin of the Atomic Scientists*.
[14] Hecht 1998.

emanate from the agency and are presented to the executive. The nuclear agency, in choosing what information to provide, and how to provide it, may thus shape the interests of the executive, and the executive, in giving or choosing not to give orders, political support, or funding, may constrain or expand the interests of the agency. The agency may anticipate the executive's preferences and make proposals that best fit their goals that the executive is also likely to accept, moving the program along their preferred path within that range of possibility.

While the executive is the actor making the final policy decision when it comes to the course of a nuclear weapons program, the set of policy ideas the executive chooses among to make that decision usually come from below. For example, Russia created a Defense Council to make major decisions on nuclear matters ranging from doctrine, to strategy, to weapons programs. But in practice, the Defense Council's ability to make decisions was limited by the nuclear agencies. Alexei Arbatov writes: "…all the decisions were always agreed [upon] in advance by assigned bureaucratic agencies. The top party leaders were never presented with a choice of viable and clear alternative policies."[15]

Remaining with the Russian case, Soviet Premier Josef Stalin provides an illustration of a strong head of state who, after becoming convinced of the importance of nuclear weapons, displayed a high level of personal interest in and oversight of the nuclear weapons program. He demanded weekly reports on the nuclear scientists' progress.[16] When he encountered resistance from one part of the military bureaucracy, he handled the problem by simply setting up a new bureau.[17] Anxious to possess nuclear weapons as

[15] In Born et al 2010, 53.
[16] Holloway 1994, 135.
[17] *Ibid*, 245.

quickly as possible, he condemned hundreds of thousands of people, many of them prisoners living in gulags, to hazardous labor in the effort to mine uranium in the USSR and Eastern Europe. Most of those prisoners were never set free, as they knew too much about the nuclear project.[18]

Yet there is evidence that even Stalin was significantly influenced by his own nuclear agency. He was reliant on his chief advisors and scientists for scientific and technical information regarding the progress and potential of the program. During the summer of 1946, Iulii Khariton, the scientific director of the nuclear weapons project, reported to Stalin on preparations for the first Soviet test of a nuclear device. Stalin pressed Khariton on details of the test but accepted his answers, even when they were not the answers Stalin wanted, and did not ask for any technical explanations.[19] In 1949, at the urging of some of his leading scientists and NKVD (state police and espionage) head L. P. Beria, he personally canceled a state physics conference to avoid disputes among physicists that would slow progress toward the bomb. In 1946, Russian nuclear scientists first presented the idea to advance the Soviet nuclear program by developing the hydrogen bomb. This follows the same pattern as the Russian decision to start a nuclear weapons program; scientists and advisors had persuaded Stalin to initiate the program. After years of theoretical research and competing development plans within the nuclear agency, formal state approval to go ahead with the project was granted in August of 1951.[20]

[18] *Ibid*, 172, 193.
[19] *Ibid*, 200-201.
[20] Von Hippel 2004, 73-74.

Nuclear Agency Influence

Certain institutional characteristics may position nuclear agencies to be able to advance their organizational preferences and have an impact on a nuclear weapons program's path. As the head of state ultimately makes decisions regarding the course of a nuclear weapons program, characteristics that allow nuclear agencies to influence the head of state matter most. The way an agency is structured affects the agency's ability to exercise influence.[21] I divide those structural characteristics into two categories: independence and origin.[22] Through statistical modeling and case studies, I find that the more influential the nuclear agency is, the greater the risk of nuclear program acceleration.

Independence

I use the term independence here to refer specifically to the extent to which an agency has the ability to exert influence over the relevant decision maker on nuclear weapons programs: the head of state. American institutions scholars have studied agency autonomy, conceptualized as the ability to act autonomously and make decisions, in two main contexts. Howell and Lewis (2002) and Wood and Bohte (2004) identified factors, like executive-legislative conflict and legislative gridlock, that affect agency design regarding insulation from executive control. Wood and Bohte used measures of agency autonomy in their model to determine the conditions under which the American political system produces more independent bureaucratic agencies.

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[21] Much of the research on this topic has been conducted within the field of American politics. A prominent example is McCubbins, Noll, and Weingast 1989, which looks at how principals may design agencies in way to limit agencies' ability to act autonomously and concludes that this *ex ante* structural design does affect agency discretion over decision making.

[22] Many of these structural choices can be identified, as they are legislated into being either in the founding legislation or in future amendments, or are recorded in other state documents. They are most difficult to identify the most secretive regimes, but even in the case of North Korea, there is some information available on the structure of nuclear agencies.

The second category of research in the U.S. case concerns the independence of regulatory agencies responsible for regulating private industry (or public activity in some cases, as in the case of the Nuclear Regulatory Commission).[23] Comparative institutional analysis of agency autonomy has focused on regulatory agencies (Maggetti 2007, Gilardi 2008, Huber and Shipan 2002) and central banking (Grilli, Masciandarao, and Tabellini 1991, Cukierman 1992).

Drawing in part on this political bureaucracy research, I select several features of nuclear bureaucracies that may influence nuclear policy making. I identify the main nuclear weapons program agency in each country and look at its entire history, from its founding onward, to determine its level of independence in each calendar year. In many states, the nuclear agency's level of independence changes over time. I ask three questions to determine where the state's nuclear agency falls on a spectrum of independence: To whom does the nuclear agency report? Does the nuclear agency fall under executive control? And does the government have oversight of the nuclear agency?

First, to whom does the nuclear agency report? The agency that reports directly to the head of state has the ability to shape its message and deliver it intact to the decision maker. Nuclear agencies that report to a cabinet minister, who then reports to the prime minister, can find their recommendations are altered, stalled, or ignored by the cabinet minister. Without direct access to the executive, those officials who enjoy such access can intervene by refusing to accept or pass along an agency's reports, advice, and proposals.[24] Without the authority to provide information and policy advice directly to the executive, the nuclear agency loses a main avenue of preference-shaping.

[23] See, for example, Wood and Waterman 1991, Huber and Shipan 2002.
[24] Halperin 2006, Chapter 9.

The importance of having the executive's ear is demonstrated by the experience of Sergey Kaftanov, Stalin's State Defense Committee Commissioner for Science. During World War II, Russian intelligence services passed along a captured notebook belonging to a German officer and filled with notes on the atomic bomb. Russian General G. I. Pokrovskii, an explosives expert, wrote that the USSR should not start work on an atomic bomb. With Russia under siege by Germany, and with the ability to build and use an atomic bomb years away, Pokrovskii believed that diverting money to such a project would not be in the best interests of his country. [25]

But Kaftanov, eager to embark upon the path to nuclear weapons, suppressed Pokrovskii's report. In a personal meeting with Stalin, he recommended that Russia begin work on nuclear weapons research. Stalin, kept ignorant of dissenting opinion, was persuaded.[26] The executive can only make decisions based on the set of options he or she believes to be available. The ability to control the information flow to the key decision maker is a critical component of bureaucratic power.

Second, does the nuclear agency fall under executive control? An agency could lie within the cabinet, or, in the U.S. case, in the Executive Office of the President. Or is the agency independent of the executive? An independent agency can develop organizational preferences and act to promote them. But an agency that falls under executive control is subject to the preferences of the head of state. A head of state with broad control over a institutionally dependent agency is better able to consolidate power and shape influence within the agency, and is more likely to have his or her own viewpoint reinforced, not challenged. The agency would have a reduced ability to influence the executive.

[25] Holloway 1994, 85.
[26] Ibid.

Whether the agency reports to the executive and whether it falls under executive control are two separate elements of agency design. For example, an agency can report to the president yet remain outside executive control; a combination which gives an agency a great deal of independence. Argentina's nuclear agency, the National Commission of Atomic Energy (CNEA), maintained this structure until 1982, when it was placed under executive control. Up until that time, the CNEA both reported to the President directly and operated independently of the cabinet.

The head of the CNEA operated with wide discretion. When the CNEA wanted to build Argentina's Atucha-2 nuclear reactor, CNEA head Castro Medero met with President Jorge Rafael Videla and requested he create a commission which would serve to justify the endeavor. Videla established the commission, when then rubber stamped plans for the reactor project. The CNEA, with official approval in hand, proceeded to invite bids from foreign firms to procure the reactor, handled the negotiations, and effectively decided which bid to accept.[27]

By having the ear and the confidence of the president, and by operating independently, outside of the direct daily control of the Argentine government, the CNEA enjoyed a high degree of autonomy. The agency was able to exert pressure on political decisions and played a large role in setting the course for the country's nuclear weapons program.[28] When the civilian government of Raúl Alfonsin took office in 1983, the CNEA was placed under executive control, becoming accountable to the foreign ministry. Its budget was cut almost in half.[29] The CNEA no longer had the autonomy (nor the privileged

[27] Sethi 1999.
[28] Ibid.
[29] Reiss 1995.

access to the head of state) required to set the nuclear agenda or even to restore its own funding.

Third, does the government have oversight of the nuclear agency? Due to the highly secretive nature of nuclear weapons programs, nuclear agencies are often free from the constraints of parliamentary intervention. To a large extent, the executive decides when to inform parliament of nuclear weapons activities, and how much information to provide. Parliamentary oversight may exist in name only, as in Israel, where a tiny and extremely secret committee theoretically serves as a check on the nuclear program, but in reality, merely approves whatever proposals may be sent its way.[30]

However, some meaningful levels of oversight do exist in some cases. Parliamentary oversight exists for at least part of the history of seven nuclear weapons programs, totaling twenty percent of the observations in my data set of these programs. Oversight is observed both in countries that have acquired nuclear weapons and continued their programs, and in those that have ended their programs. Fiscal authority over the nuclear agency is the most common mechanism by which parliament can exercise control over nuclear programs.

This component of institutional design is not predicated on a hostile parliament. A majority of members of parliament may favor the nuclear agency's agenda. Yet even if parliament supports the pursuit of nuclear weapons, its ability to intervene in the policy process should slow a program, extending the time to a decision to advance a program forwards. However, because the ability of parliament to exert influence over a nuclear

[30] Cohen 2010, 200. Members of this committee are removed from the nuclear program to the extent that one of their only interactions with the nuclear apparatus is their occasional guided tours of the Dimona nuclear facility.

weapons program has less of a bearing on agency independence overall than do the other two factors of executive access and executive independence, it is weighted as the least important of the three components.

A clear case of strong oversight occurred in the United States during the existence of the Joint Committee on Atomic Energy (JCAE). This Congressional committee was statutorily permitted to stay highly informed of the work of the Atomic Energy Commission (AEC), and the committee fully exercised that right. The JCAE has been described as "dominant" over the AEC; at times, the AEC had to follow the policy guidance of the JCAE.[31] Although the influence of the JCAE declined when the AEC was replaced by the Nuclear Regulatory Commission in 1977, by then, Congress had begun exercising its power of the purse, taking on more of a role in nuclear weapons policy.[32]

Origin

When a new agency is added to a state's bureaucracy, the means by which it is created can affect how insulated it is from the rest of the government. An agency protected by formal legal authority is more difficult for heads of state to weaken or eliminate. Such agencies are able to exercise more influence on the executive because their survival in the state bureaucracy is relatively secure. An agency with formal legal codification is more likely to have the authority to insert itself into state policy making and better pursue its preferences.

I establish three categories of legal formality, which I term the agency's "origin" type. These types ranging from strongest to weakest: An agency's codification into law via a parliamentary act or bill; an executive decree establishing an agency; and the informal

[31] Davis 2004.
[32] Lindsay 1991.

creation of an agency without official, legal documentation. If the head of state sets up the nuclear agency unilaterally, he or she can design it in order to maximize executive control over the agency. But if the legislature creates the agency, that agency may be more insulated from executive control.[33] Legal autonomy granted by parliament in an act is the most difficult for a head of state to remove.

Origin does not simply correspond to a state's level of democracy.[34] The United States and Israel both created nuclear agencies as strong democracies, but the United States codified its agency into law, while Israel eschewed formality. Iran was a monarchy at the time the Shah created the Atomic Energy Organization of Iran, yet legally, the AEOI was created via both a parliamentary act along with the Shah's decree.[35] Brazil is another example of an autocratic regime that used parliamentary authority to formalize the creation of its nuclear agency.

Independence and origin do not go hand in hand, either. There is wide variation in *how* agencies are formed (origin) and what *characteristics* are incorporated into their designs (independence). There is no statistical correlation between origin and independence. For example, Australia's nuclear agency was established by parliamentary act, but had a low level of agency independence. South Africa and Sweden followed similar patterns. But the nuclear agencies of both Brazil and France were also established by parliamentary acts, and enjoyed high levels of independence. Nor is independence limited to agencies established by codification into law: Argentina's nuclear agency was

[33] Howell and Lewis 2002.
[34] I use democratic and autocratic measures of authority in states from Marshall, Monty G. and Keith Jaggers. 2002. *Polity IV Project: Political Regime Characteristics and Transitions, 1800-2002*. Version p4v2002e. College Park, MD: Center for International Development and Conflict Management, University of Maryland.
[35] Although parliament's act was largely a rubber stamp approving the Shah's decree, the outcome, that the AEOI was codified into law and thus further insulated from executive control, is what is matters here. See Patrikarakos 2012, 21.

established by decree, but for years was one of the most autonomous nuclear agencies in the world. Israel's nuclear agency was created informally, without any documentation, yet it, too, has enjoyed great independence.

Three vignettes illustrate the importance of the origin of the nuclear agency: Iran, where legal codification helped the agency survive the Iranian Revolution; India, with a prototypically high-influence agency created by executive decree; and Argentina, which demonstrates what can go wrong when an agency lacks formal shielding from executive control.

Iran: Atomic Energy Organization of Iran

A highly independent agency is able to influence the executive, but is not necessarily insulated from political interference. The Atomic Energy Organization of Iran (AEOI) enjoyed a high level of independence, but experienced a loss of that control in the aftermath of the Iranian Revolution. Due in part to the codification into law of the institutional structures of the AEOI, the organization was able to survive and reemerge within the succeeding two years.

The Act of 1974 of the Atomic Energy Organization of Iran was brought into force by the Shah's Royal Decree of 11 July. The AEOI was given "legal personality and financial independence."[36] The head of the AEOI, physicist Akbar Etemad, was granted an enormous amount of autonomy, with the power to make all decisions involving budget and hiring. Since Etemad had direct access to the Shah, he was able to go to the Shah whenever he faced bureaucratic obstacles, which the Shah would swiftly overrule on Etemad's behalf.[37]

[36] Nuclear Law Bulletin, 1975, No. 17, accessed via: www.oecd-nea.org
[37] Patrikarakos 2012, 21-22. The Shah's manner in dealing with those who stood in Etemad's way is characterized as "angry," and top ministers expressed envy at Etemad's power to use state resources.

This remarkable personal power was used for very different purposes by the Iranian government after the Revolution in 1979. The new regime felt enormous political pressure to roll back a "Western" program that was perceived as a drain on the state coffers. A well-connected geologist who had fervently taken part in the revolutionary movement, Fereydun Sahabi, was appointed as the new head of the AEOI. Dedicated to the ideals of the revolution and disappointed that many of the AEOI staff were uninvolved in politics, he was virulently opposed to the nuclear program and was intent on eliminating every nuclear activity in Iran. Almost all nuclear programs were shut down, leaving only the nuclear facility at Bushehr operational, and the only reason that facility remained intact was because Sahabi tried but failed to find some other use for the specialized plant and equipment. Foreign nuclear contracts were suspended for review by the new regime, or canceled outright.[38]

Yet despite the extreme anti-nuclear philosophy embraced by the government, the AEOI, although left in a state of suspended activity, survived largely intact. Its formal structure and powers, codified into law, remained in place. The regime tried to eviscerate the program, but it left the institution untouched. By 1980 and 1981, influential people within the government had begun pressing for the rejuvenation of the nuclear program. When Sahabi was removed from his post and replaced by a nuclear scientist and AEOI director, Reza Amrollahi, the program quickly started back up again.[39] The government, despite its hostility, had never dissolved the AEOI, as nuclear agencies have been in other countries. The nuclear programs had been halted but not destroyed, and the decision to advance the program forward again was able to take place within a short time frame.

[38] *Ibid*, 95-101.
[39] *Ibid*, 103.

India: Atomic Energy Commission

India's highly independent nuclear agency has been called "organizationally insulated" and a nuclear "enclave," wherein the head of the Atomic Energy Commission (AEC) has been responsible only to the Prime Minister, and its facility in Bombay is physically separated from the national bureaucracy in New Delhi.[40] Decision making occurs without "formal checking and balancing mechanisms," and oversight is limited.[41] The AEC does not only enjoy administrative and bureaucratic autonomy, but also financial.[42] This autonomy was established by presidential decree recorded in a resolution. On March 24, 1958, the resolution was "laid on the Table" of the Lok Sabha (parliament) by Prime Minister Nehru.[43] In doing this, Nehru was submitting the decree to the parliament, which then had the opportunity to object to it on the grounds of non-compliance with statutory or constitutional precepts.

The resolution grants the AEC "full executive and financial powers" and institutionalizes a powerful dual leadership role in which the chair of the AEC is simultaneously the Secretary of the Department of Atomic Energy (DAE) that houses the AEC. The document goes on to reiterate this extraordinary status with these words: "the Commission shall have the powers of the Government of India, both administrative and financial, for carrying out the work of the [DAE]." The AEC is given the authority to originate and implement policy for the DAE, as well as to prepare, and submit to the government, the DAE budget. The Chairman reports directly to the Prime Minister and has

[40] Abraham 1992, Flank 1993.
[41] Perkovich 1999, 448.
[42] Sidhu in Born et al 2010, 174.
[43] Government of India Resolution No. 13/7/58-Adm. of March 1, 1958. Accessed via the Indian Department of Atomic Energy website at http://dae.nic.in.

the power to grant authority and responsibility to each member of the Commission as he sees fit.[44]

The decree, backed by the Prime Minister, was able to insulate the AEC from challenges to its authority just six months later. Recall Dr. Meghnad Saha, the influential nuclear scientist who had once hoped to lead India's nuclear program. When the AEC was formed and Saha was excluded from its leadership, he turned to leading politicians and political elite to attempt to reshape the commission, in part to make it less secretive.[45] Saha was himself a member of parliament at the time. Yet despite his political position and influence, and his national scientific reputation, Saha was unable to make any headway. The AEC was able to successfully deflect his critique and political attack because of the Prime Minister's support and parliament's unwillingness to take formal action to overturn the decree.

A decree, however, does not insulate an agency to the extent that legislation can. If the Prime Minister had not so strongly supported the decree, a concerted attack on the institutional structure of the AEC may have led to a different outcome. If an executive opposes the nuclear weapons program, a decree provides more protection than an informal understanding, but less than a law.

Argentina: National Commission of Atomic Energy

Earlier, I discussed the high level of independence enjoyed by the Argentine National Commission of Atomic Energy (CNEA). For years, the agency operated outside of executive control, had broad authority to act on behalf of the state, and had a great deal of influence over the president. The CNEA was established by presidential decree in 1950 on

[44] Ibid.
[45] Abraham 1998, 74.

the authority of President Juan Perón.[46] It was directly responsible to the president and given governing power over "nuclear energy matters."[47] This arrangement enabled the CNEA to pursue its organizational preferences with relative ease, as long as it had the support of the head of state.

However, executive support ended in 1983 with the election of Raúl Alfonsin to the presidency. Alfonsin was able to gut the agency quickly and thoroughly. He removed the powerful head of the CNEA and installed his own appointee, set the agency under executive control by placing it under the authority of the Foreign Ministry, and reduced the agency's budget by 40% in a single year.[48] How was such a powerful agency so easily dismantled?

The CNEA's institutional authority was based on a past presidential decree disdained by the new regime and unprotected by formal parliamentary law. Alfonsin did not need to secure the support of a new parliament or constitutional committee to take such drastic action; he simply undid a thirty-three year-old order. With executive support, a decree was enough to establish a powerful and independent agency, but when that support was lost, the legal institutionalization of the CNEA did not offer strong enough protection to prevent the new president from reorganizing the agency to his liking.

Testing the Theory

I test this theory using two approaches: statistical modeling, and case studies. The case studies appear in Chapters 5 and 6 and provide historical context supporting the idea that the more influential a state's nuclear agency is, the more likely the government will be

[46] Decree No. 10.936.
[47] Leventhal and Tanzer 1992.
[48] Reiss 1995.

to decide to accelerate its nuclear weapons program. The statistical model uses a new and original data set that I created by examining government documents and nuclear program histories. I compiled a complete list of all political decisions to accelerate, decelerate, or stop a nuclear weapons program that occurred in each country that has ever started such a program. This account represents the best information we have on nuclear programs at the present time.

I use an event history model to examine the risk that a government will decide to accelerate its nuclear weapons program. Only states that have already decided to begin a nuclear weapons program (see Chapter 2) are included in this analysis. More details on this model can be found in Appendices 6-8. Nuclear agency influence is measured in two ways: independence and origin. These two measures are not correlated. The scale for the origin of the nuclear agency has three levels, listed here in order from the highest level of formality to the lowest: whether the agency was created by act, decree, or informally. If an agency is dissolved and a new agency is formed, I begin in that year to code the level of formality of the successor agency's creation.

To measure a nuclear agency's independence in each year, I created an index composed of several institutional features. Following my theory of agency independence, I ask three questions to determine where the state's nuclear agency falls on a spectrum of independence. First, to whom does the nuclear agency report? If the agency reports to the head of state, it receives the highest score of independence in this component of the index; followed by reporting to the Politburo or equivalent, or military; and at the lowest end, reporting to a minister. Second, does the nuclear agency fall under executive control? An agency that falls within strong executive control, such as within the cabinet, receives the

lowest score of independence for this component, and an agency that is independent of the executive with its own executive powers receives the highest score. Third, does the government have oversight of the nuclear agency? This component is weighted the least of the three, as it is the weakest indicator of independence, given the limited nature of any oversight of secretive nuclear programs. An agency that is subject to parliamentary oversight receives the highest score of independence, while those with no oversight, or oversight in name only, receive the lowest score.

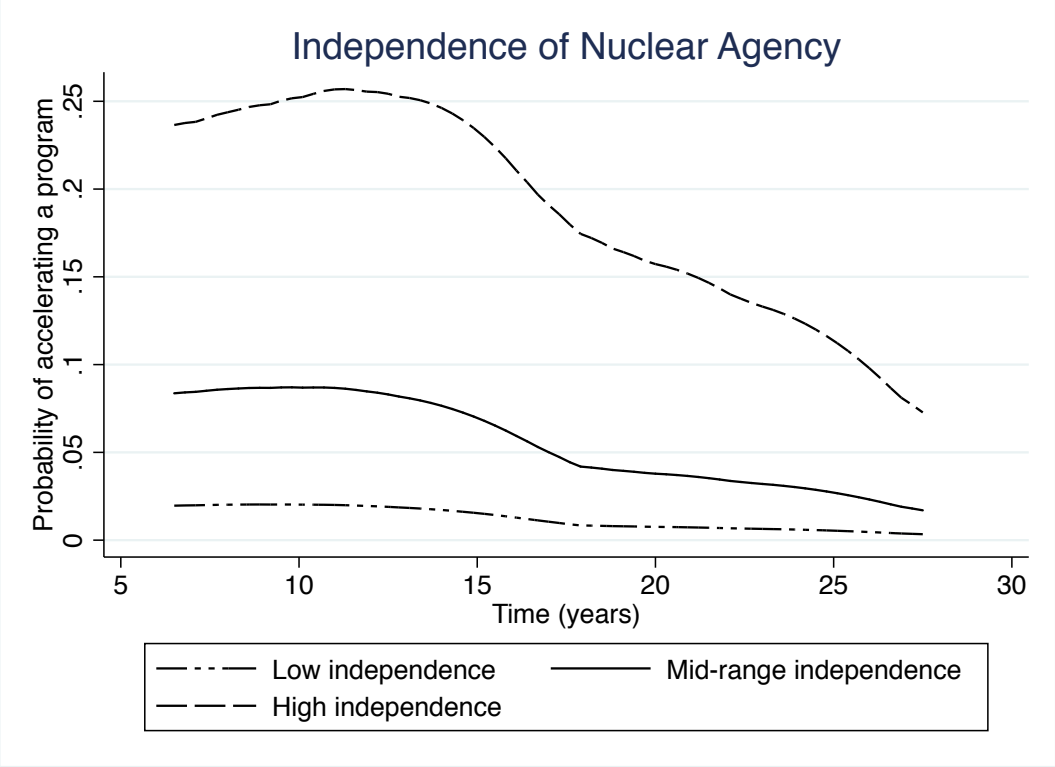
The event history models consistently show that both agency independence and origin have a statistically significant impact on the risk of making a decision to accelerate a nuclear program. (See Appendix 8 for the table of results.) As expected, the models indicate that the more independent an agency is, the more likely a state is to accelerate its nuclear weapons program, and that the more formally institutionalized the agency was when it was created, the more likely a state is to accelerate its nuclear weapons program.

Do the institutional characteristics of nuclear agencies affect agency influence on the executive? There is strong support from the model indicating that more independent, and more formally created agencies, do increase the risk of a state deciding to advance its nuclear weapons program. The risk of accelerating a program increases by a factor of two with each unit increase in the level of agency independence. From the lowest level of independence to the highest, the difference in risk is a factor of ten. I have exceptionally high confidence in this result; the likelihood that agency independence does not affect the risk of a decision is statistically almost zero.

The level of legal formality an agency receives at its creation increases by a factor of three with each unit increase in formality; the difference of the impact on risk between an

informally created agency and one that has been codified into law, is a factor of six. The probability that an agency's origin does not affect the risk of a decision is statistically less than one percent.

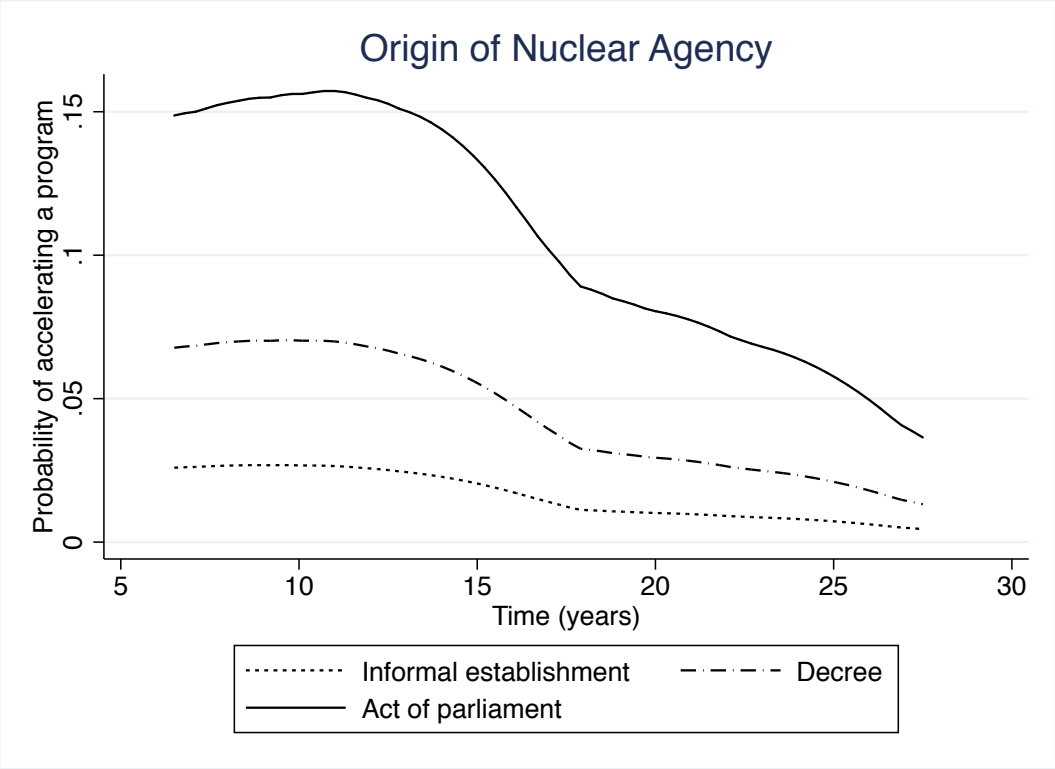
Figure 4.1 Hazard rate of decision to accelerate nuclear weapons program: Independence



As I have discussed in Chapters 2 and 3, the hazard rate measures the likelihood that the event modeled will occur in a given year, conditional on its not yet having occurred at that time. In Figure 4.1, I compare the hazard rate of the decision to accelerate a nuclear weapons program at three different levels of a nuclear agency's independence. At higher levels of independence, the risk of acceleration becomes much greater; for the most independent agencies, there is a 25% probability of a state decision to accelerate. The risk of a decision is less than 3% when the agency has very little independence. The risk of a

decision to accelerate is highest during the first ten years after the last decision to start or accelerate a nuclear weapons program.

Figure 4.2 Hazard rate of decision to accelerate nuclear weapons program: Origin



Examining the hazard rates for each of the three levels of a nuclear agency's legal formality again displays the impact certain institutional types of nuclear agencies can have on decision making. In Figure 4.2, I graph the hazard rate of the decision to accelerate a nuclear weapons program when an agency has been created without formal legal documentation, by executive decree, and by codification into law. The greater the level of formality with which the agency was established, the higher the risk that a state will decide to accelerate. States housing nuclear agencies that have been codified into law have roughly a 15% probability of deciding to accelerate during the first ten years after a program begins, or after the most recent decision to accelerate. Compare this risk with that of an

informally established agency. States with agencies not granted formal legal institutionalization have only about a 3% probability of deciding to accelerate.

Why are nuclear agencies particularly adept at translating these institutional characteristics into influence? Nuclear agencies benefit from informational asymmetry. They are able to shape preferences by manipulating information that those outside the agency cannot fully access or even understand. Max Weber suggested that bureaucrats, as experts, control information in order to gain power over "dilettante" politicians. While authority lies with the political office holder, power lies with the agency, which holds an informational advantage.[49]

Nuclear agencies have a particularly strong informational advantage because of three special attributes: Secrecy, the highly technical nature of nuclear science, and the awe and fear that surrounds the topic of nuclear weapons. These three qualities of nuclear weapons programs make nuclear agencies particularly able to influence policy making.

Secrecy

The knowledge held by nuclear agencies is shielded by extremely high levels of security. Nuclear weapons programs, along with espionage programs, are among a state's most secretive undertakings. Information is compartmentalized, meaning that even people who have the security clearance necessary to access the information will need additional authorization to view compartmented information. This is a common practice across countries. Compartmentalization ensures that the nuclear agency can easily, with little

[49] Weber 1946.

administrative cost, prevent national security officials, holders of high elected office, and other members of the nuclear agency itself from accessing knowledge about the program.

This extreme secrecy augments the capacity of nuclear agencies to maintain control of information. Secrecy provides agencies with more leeway to reveal what advances the agency's interests and withhold what does not. This limits the power of the head of state and other high-level decision makers by narrowing the set of policy options decision makers have to choose among. Compartmentalization in particular limits the number of people who can discuss policy options, making the influence of the agency even more potent.

In Stalin's Soviet Union, secrecy was so stringent that even scientific terms became classified. Sensitive terms were give code words ("zero points" for "neutrons" is one example), and these codes could not be trusted to the staff members typing the reports but had to be written in later by hand. Classified information was compartmentalized, and only Khariton (the director of the project) had access to everything. Anxiety levels surrounding this heightened secrecy were so high that recurring nightmares about mishandling classified material, and even a suicide, were reported.[50] Soviet advisors working in China to assist Chinese scientists with their early efforts to develop nuclear weapons set up similarly strict security measures there, cloaking the project in "extreme secrecy."[51]

The Israeli Atomic Energy Commission (IAEC) is characterized by Avner Cohen as being the most secretive and guarded governmental agency in Israel. Certain words, like "nuclear weapons," were never used, even in classified documents.[52] The program was so

[50] Holloway 1994, 202.
[51] Lewis and Xue 1998, 48.
[52] In Born et al 2010, 156.

highly compartmentalized that even the IAEC itself was excluded for a few years from the Dimona project, Israel's first nuclear facility, so that it could convincingly serve as a civilian cover for the militarized project.[53] (By the mid-1960s, the IAEC was restored as the agency responsible for nuclear weapons programs.)

This kind of secrecy exists not just in these examples, but across cases. It is a common characteristic of nuclear weapons programs due to their extraordinary destructive power. Privileged access to information bolsters the influence the agency has on the decision makers who must rely on the keepers of that classified knowledge.

Technical Opacity

Nuclear weapons came to exist because scientists discovered techniques for adding an extra neutron to an unstable isotope of uranium, splitting the nucleus in two. This process, called nuclear fission, releases energy. Millions of times more energy is released from a fission reaction than from a chemical reaction such as a TNT explosion, which is why nuclear weapons are so incredibly destructive. The fission process is highly technical, requiring specifically calibrated equipment and complex facilities, and the science underlying the technology is difficult to grasp.

Because of the complex and technical nature of nuclear weapons programs, most politicians have "a limited understanding of what a nuclear weapon is and what it can and cannot do."[54] Many decision makers simply do not realize what is needed for a successful program, what the differences are between types of reactions and weaponry, and what kind of timelines or budgets are reasonable. The technology is too opaque to the non-

[53] Cohen 2010, 92.
[54] Cheema in Born et al 2010, 213, referring specifically to the Pakistan case.

scientist. In his book *Pointing the Way*, former UK Prime Minister Harold MacMillion wrote that heads of state, ministers of defense, and cabinets are "handicapped" because the sophisticated weapons they authorize are so technical and unknown. They exist too far out of the realm of normal human experience.[55]

The director of the Russian nuclear project, Dr. Igor Kurchatov, organized seminars to explain some of the science behind uranium processes, but the managers attending them understood almost nothing. Boris Vannikov, a high-level state and party official involved with nuclear program decision making, was an engineer with a previous career in industry. Yet even he did not understand what the nuclear scientists were attempting to explain to him regarding their projects and their resource needs. Vannikov felt "powerless" because of the "invisible and intangible" nature of the atom, and talked about how the words the scientists were using were "not in my vocabulary."[56]

The nuclear agency is often the single authority on the technical aspects of the nuclear program. Often, it is also the main authority on the financial, organizational, and administrative aspects as well. Thus, nuclear agencies with greater influence over their state's chief decision makers – those with a high level of independence and legal insularity – will have a greater ability to drive policy making.

Consider one of the highest level decision makers in the Soviet Union during Stalin's pursuit of nuclear weapons, L. P. Beria. As chair of the Special Committee, he led the most important decision making on the nuclear project outside of Stalin himself. A few days after Russia's first nuclear reactor went critical, a key milestone in any nuclear program, Beria

[55] From Scilla Elworthy, "Nuclear Weapons Decision-making and Authority," pp. 165-176, in Marsh and Fraser 1989.
[56] Holloway 1994, 137.

visited the facility for a demonstration. When the chain reaction began, and the scientists exclaimed over their success, Beria, expecting something more visually impressive than the movement of gauges and instruments, expressed disappointment. “Is that all?” he complained. He asked to go to the reactor to see what was happening, and Kurchatov had to stop him, explaining that it would be too dangerous.[57] Beria did not understand the most basic scientific principles behind the fission process; he did not realize that the process would be invisible, nor that being brought to the reactor would expose his body to radiation.

It is unsurprising, then, that the nuclear bureaucracy made suggestions that were brought to Stalin, who then consulted with various scientists about those suggestions. This is part of the common pattern across states where policy options are shaped from below, and heads of state are reactive, not proactive.

Awe and mysticism

A sense of awe, and even mysticism, pervades the topic of nuclear weapons. First, human beings have a tendency to feel awed by extremely large or small phenomena. Most people have shared the common experience of feeling insignificant when contemplating the vast expanse of the stars in the night sky. Some remember coming to the realization, when peering through a classroom microscope to view an amoeba on a slide plate, that an entire unseen world of invisible organisms exists around us. These moments recall the innate thrill that contains both amazement and unease, the thrill that comes from trying to comprehend such extremes of scale.

[57] Holloway 1994, 182.

In the same way, sub-atomic science evokes strong feelings of awe amongst most people who attempt to learn something about it. The notion that such devastating energy can be emitted from nuclear reactions that are too tiny to see, reactions that actually split apart the nuclei of atoms – what we have learned are the fundamental "building blocks" that compose all matter – is astonishing.

Second, nuclear weapons are incomprehensibly powerful. Humans have witnessed the terrible effects of fission weapons on the residents and structures of Hiroshima and Nagasaki. A single bomb could reduce whole swaths of the cities to rubble, but even more, caused horrific damage to the people who were caught in the blast, or who survived, but then suffered the effects of radiation. Photographs of some of the injured have a nightmarish quality, particularly the gruesome severity of thermal burns. Fusion weapons (also called thermonuclear weapons, or hydrogen bombs) are many, many times more powerful, but have never been used.[58]

Despite this history, a great deal of anecdotal evidence supports the idea that many politicians focus much more on the power of the weapons than on the human toll. The sheer might of nuclear weapons is something exciting, thrilling, larger than life. In the mid-twentieth century, Australian cabinet-level officials admitted their ignorance of nuclear matters while professing great enthusiasm for the weapons.[59] As China worked to master nuclear fission, Chairman Mao Zedong led a meeting of all senior members of the Politburo in which nuclear scientists delivered a lecture on basic nuclear physics. Exuberant over the

[58] In my experience, audiences actually gasp aloud when I present maps displaying the enormous blast radius of a small fusion weapon. The magnitude of the weapon's potential effect is overwhelming.
[59] Moyal 1975, 370.

goal of acquiring nuclear weapons, Politburo members took turns "playing with a Geiger counter to hear it click," beaming with joy and excitement.[60]

This embrace of the power of nuclear weapons, driven partly by ignorance of the reality of the aftermath of a nuclear strike, is not a historical relic of the early days of nuclear development, but persists today. A recent study in the United States demonstrated that a surprisingly high percentage of Americans (in some cases, more than two-thirds), when given a specific scenario involving an adversarial country, would support the use of nuclear weapons against that adversary. The researchers classified the American public as having only a "weak aversion" to the use of nuclear weapons.[61] While this particular study does not identify the beliefs of non-Americans, nor of Americans in the political elite, it confirms what many agree is a general lack of awareness of the human cost of nuclear attack.

When the United States was developing its Atlas ICBMs, decision makers had to determine what size warheads the missiles should carry. Herbert York, a member of the missile science committee and the chief scientists in the Pentagon, recalled how the decision to use a warhead with a one-megaton explosive yield was made:

> "So, why 1.0 megaton? The answer is because and only because one million is a particularly round number in our culture. . . It really was that mystical, and I was one of the mystics. Thus, the actual physical size of the first Atlas warhead and the number of people it would kill were determined by the fact that human beings have two hands with five fingers each and therefore count by tens. . . It really was that arbitrary, and what's more, that same arbitrariness has stayed with us."[62]

[60] Lewis and Xue 1988, 38.
[61] Press et al 2013.
[62] York 1971, 88-90.

The mysticism surrounding these larger-than-life weapons is also identified by others. Shimon Peres, speaking of Israeli Prime Minister David Ben-Gurion, said: "Ben-Gurion believed that Science could compensate us for what Nature has denied us . . . [his] romantic, even mystical faith in science and technology sustained his utopian vision of a blossoming Negev desert and the use of nuclear power to desalinate sea water."[63] The vision Peres attributes to Ben-Gurion sounds more like science fiction than like science. Indeed, nuclear science does seem like science fiction to many politicians. Nuclear energy is so powerful as to solve energy problems and water shortages; nuclear weapons are so powerful as to deter enemies and confer global prestige. Such tools can invoke a mystical sense of being too good to be true.

Perhaps it is part of our human nature to feel in awe of forces that are just beyond our understanding. The awe most decision makers feel regarding nuclear weapons tends to leave them feeling excited by a magnitude of power that is difficult to imagine, enthusiastic about the promise that the technology holds, and thrilled by the prospect of possessing such a capability. If scientists themselves agree to a round number of 1.0 megaton warheads because it sounds good – because it sounds "mystical" – then how can one expect a head of state or his or her close senior advisors to delve into the math and science and disagree? The thrill, and the fear, that politicians experience when it comes to nuclear matters affords unique influence to the masters of nuclear science, and thus to the nuclear agency.

[63] In Cohen 1998, footnote 353.

Conclusion

Having the authority to make a decision is only one component of decision making. Heads of state have preferences that may be shaped by influential people and institutions. Certain institutional characteristics affect an agency's influence on the executive. The characteristics I identify are agency independence and agency origin. The more independent a state's nuclear agency is, and the more formal its origin, the more likely that state is to make a decision to accelerate its nuclear weapons program.

An independent nuclear agency is more likely to be able to set nuclear policy from the bottom up, according to its own agendas and practices. The more independent the nuclear agency is from political control, the greater the ability of the agency to try to persuade decision makers to follow the agency's preferred policies. Direct access to the head of state, a position in the government bureaucracy outside of executive control, and freedom from government oversight, all contribute to agency independence. The way an agency is structured affects the agency's ability to exercise influence.

A nuclear agency's origin is important because the means by which an agency is created or re-created can affect how insulated it is from the rest of the government. An agency protected by formal legal authority is more difficult for heads of state to weaken or eliminate. Such agencies are able to pursue their own preferences and exercise more influence on the executive because their survival in the state bureaucracy is relatively secure.

Nuclear agencies can take particular advantage of these institutional structures because these agencies benefit from informational asymmetry. They are able to shape preferences by manipulating information that those outside the agency cannot fully access

or even understand. This particularly strong informational advantage stems from three special attributes that serve to limit outside knowledge of the nuclear program: Secrecy, the highly technical nature of nuclear science, and the awe and fear that surround the topic of nuclear weapons.

Domestic institutional structures affect a state's risk of accelerating its nuclear weapons program. In Chapter 5, I conduct three case studies to examine how states make the decision to start a nuclear weapons program, and how civil-military relations and the institutional characteristics of nuclear agencies have affected the path and pace of the nuclear weapons programs in Brazil, Pakistan, and the United States.

CHAPTER 5

Case Studies

Introduction

In the previous chapters, I have used event history models to test theories explaining the path and pace of nuclear weapons programs. First, both state capacity and motivation affect the likelihood that a state will decide to start a nuclear weapons program. States with nuclear reactor experience are more likely to make the decision to pursue the military uses of nuclear power. A state with a nuclear strategic rival is at significantly higher risk of starting its own nuclear weapons program. And at high levels of conventional threat from a rival or rivals, the probability that a state will begin a program increases. Second, the more militarized a state's civil-military relations are, the less likely the government will be to accelerate its nuclear weapons program. Third, more independent nuclear bureaucracies are better able to influence leaders to increase the pace of nuclear weapons programs.

I explore these dynamics in three case studies: Pakistan, Brazil, and the United States. Decision makers are influenced by both domestic and international interests and pressures. The nature of nuclear weapons programs – the extreme levels of secrecy, the highly sophisticated science and technology that leads to politicians' reliance on expert

views, and the mysticism and awe which pervade the topic – enhance the influence of the nuclear bureaucracy. And militaries have institutional interests that tend to lead them to support allocating resources to developing better conventional weapons for use in conflict rather than nuclear weapons, which many military officers consider to be unusable, or at the very least, unfamiliar, war fighting tools. Executives can be influenced by the nuclear bureaucracy and the military, as these organizations may offer sets of policy choices to the executive and advocate for their preferred policies within that set.

I examine nuclear weapons program decision in three countries: Brazil, Pakistan, and the United States. Statistical modeling allowed me to test broad theories of state decision making behavior by analyzing start decisions using all states in the world from 1939, and pace decisions for all nuclear weapons-seeking states. Case studies provide the benefit of adding context and depth to broad theorizing. In each of the three cases, I show how domestic institutional factors and the external security environment played a part – or did not – in key nuclear weapons program decisions and over the life of the program. I begin with Brazil, a country which ultimately ended its nuclear program, and then turn to two states with programs still in existence: Pakistan, a regional power that began its nuclear weapons program almost twenty years after the end of World War II, and the United States, one of the original nuclear weapons states.

Brazil

Brazil has been involved in nuclear energy from the beginning of the international pursuit of nuclear weapons. In the 1940s, Brazil mined domestic reserves of uranium for the Manhattan Project in the United States. In 1947, the Brazilian National Security Council

discussed possible nuclear development in detail. While the majority of the meeting concerned the civilian use of nuclear energy, council members also discussed the importance of being prepared for fighting future wars. A representative of the Brazilian Navy, Admiral Alvaro Alberto, conveyed the Navy's eagerness to pursue nuclear research and indicated that he was ready to send officers abroad to study the relevant aspects of nuclear science.[1] When Brazil began its civilian nuclear program in 1951, Alberto was at the helm. Under his direction, Brazil embarked upon a broad program that utilized foreign assistance and left out no aspect of nuclear energy production.[2]

Although military interests had already been linked with the civilian program, the endeavor remained peaceful during the 1950s and 1960s. Brazil's first research reactor, provided by the United States, started operating in 1956. That same year, a new president had come to power and, by decree, established the National Commission of Nuclear Energy (CNEN) as Brazil's chief nuclear agency.[3] CNEN was placed under the authority of the presidency and was later codified into law by an act of parliament.[4] By 1965, Brazil had built its own research reactor, with assistance from the United States.[5]

In 1964, several Brazilian Army generals led a military coup that deposed the democratically elected president, João Goulart, and instituted what would become a twenty-one year military regime. Three years later, the second president of this regime, Marshal Arthur da Costa e Silva, created a plan for developing nuclear energy that led Brazil to seek out foreign partners. Costa e Silva sought to purchase nuclear plants outright,

[1] Minutes of the Tenth Session of the Brazilian National Security Council: August 17, 1947. Document available through the Wilson Center, accessed via Patti 2011.
http://digitalarchive.wilsoncenter.org/document/116912
[2] Patti 2011.
[3] Decree No. 40.110 of 10 October 1956.
[4] Leventhal and Tanzer 1992, Patti 2011.
[5] Solingen 1990.

planning to construct those facilities in Brazil outside of the restrictions soon to be imposed by the international non-proliferation regime. At the time he was developing his vision of the course of nuclear development in Brazil, negotiations regarding the Nuclear Non-Proliferation Treaty were in their later stages, and Costa e Silva was staunchly opposed to the proposed language that aimed to prevent non-nuclear weapons states from engaging in activities that could lead to the development of nuclear weapons.[6] Building an indigenous capacity to pursue nuclear energy activities would allow Brazil to be more independent amidst tightening restrictions.

It took several years for Costa e Silva's plans to come to fruition, a typical situation in nuclear programs. Often, the political decision and the visible results of that decision lie years apart. In 1971, CNEN entered into a contract with Westinghouse, a U.S. firm, to build a nuclear power plant, with fuel provided by the United States Atomic Energy Commission.[7] But in 1974, after India conducted its first nuclear test, U.S. policy regarding nuclear assistance changed dramatically. The United States began meeting with other nuclear supplier nations to discuss ways to prevent the spread of certain types of nuclear technology – particularly technology related to the enrichment and reprocessing of uranium.[8] This kind of technology is termed "dual use," as it can be used for both civilian and military purposes; once a state has the ability to enrich or reprocess uranium, it can potentially create weapons-grade uranium (through enrichment) or plutonium (through uranium enrichment and then reprocessing). Indeed, José Goldemberg, former Secretary of State of Science and Technology, has claimed that the government used the worldwide oil

[6] Patti 2011.
[7] Ibid.
[8] Spector 1984.

crisis of 1973 as a cover. According to Goldemberg, the government justified the acquisition of nuclear technology as necessary for domestic energy consumption in order to conceal its interest in nuclear weaponry.[9]

The government of Brazil responded by turning to West Germany, signing an agreement in 1975 to obtain two nuclear reactors, a uranium enrichment plant, and a reprocessing plant (for plutonium). This would move Brazil closer to nuclear independence, promising the national control of the entire nuclear fuel cycle, from exploration and mining all the way to waste disposal.[10] The U.S. government worked throughout the late 1970s, and particularly during the Carter administration, to try to disrupt and discourage West German nuclear assistance, heightening the Brazilian government's interest in nuclear independence.[11]

By 1978, the Brazilian government was ready to take the next step toward a militarized nuclear program. It was becoming clear that the technology obtained from the Brazilian-German partnership was not going to be sufficient to grant Brazil full control of the fuel cycle, hinging on Brazil's inability to produce a gaseous form of natural uranium, uranium hexafluoride (UF_6), that is an important step of the enrichment process.[12] Concerned by this critical technological gap, the Brazilian National Security Council discussed how to proceed.[13] Over the next year, the objectives of the Brazilian government expanded beyond the production of UF_6 to encompass an entire secret nuclear program.[14] President João Figueiredo gave documented, formal authorization of an autonomous

[9] Kassenova 2014.
[10] Reiss 1995, Leventhal and Tanzer 1992.
[11] Ibid.
[12] Kassanova 2014.
[13] Patti 2011.
[14] Ibid.

nuclear project, free from international safeguards and coordinated by CNEN, in 1979.[15] While National Security Council discussions indicate that some secret activities were already underway, the official, political decision to initiate the program can be dated to this 1979 authorization.[16]

This clandestine project, the Brazilian Autonomous Program of Nuclear Technology (PATN), was deemed the "parallel program," as it paralleled the civilian program at Brazil's nuclear industry agency, Nuclebrás.[17] Coordinated by CNEN, the project had three prongs, each one led by a different branch of the armed forces. According to National Security Council *Exposição de Motivos* (Explanatory Memorandum) no. 011/85, one of Brazil's objectives in establishing the parallel program was "to create the necessary conditions to assure for the Nation the complete and independent mastery of the nuclear fuel cycle *and all its forms of application*" (emphasis added). As governments that are secretly pursuing nuclear weapons do not explicitly record their plans to do so in writing, this kind of phrasing is a common way to refer to militarized nuclear projects in coded language.[18]

Details of each of the three projects have been public knowledge since the mid-1980s. The Air Force pursued laser uranium enrichment and the development of nuclear

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[15] Until recently, the precise timing of the government's decision to authorize Brazil's parallel program was unclear, and estimates ranged from 1974 to 1979. It now appears that some activities may have begun as early as 1978. Declassified Brazilian documents obtained by the Getulio Vargas Foundation and made publicly available by the Woodrow Wilson Center refer to the parallel program. An *aviso* (notice) from the General Secretariat of the National Security Council indicates that formal, documented authorization for the parallel program came from the president in 1979. *Aviso* no. 135/79 of 18 June 1979, from the General Secretariat of the National Security Council, accessed via the Wilson Center at http://digitalarchive.wilsoncenter.org/document/116916

[16] Aviso 135/79 records concern over "the application of IAEA safeguards on the activities underway at IPEN."

[17] Barletta 1997, 6.

[18] An emphasis at the end of the memo that the program was a peaceful one is also commonly found in the written documents of all states with nuclear programs, including those that are pursuing nuclear weapons. Such a statement confirms neither the presence nor absence of a weapons program and should not be taken at face value.

explosives. The Army worked to develop graphite reactors, including a highly secret model, based on a Manhattan Project reactor, with the capacity to produce plutonium.[19] The Navy's program was the most ambitious, and included uranium enrichment via centrifuge technology, along with developing nuclear marine propulsion for submarines. CNEN, in addition to coordinating the various projects housed in the armed forces, embarked upon its own work: to produce uranium compounds for the various military projects, to reprocess uranium to produce plutonium, and to develop supporting technologies.[20]

The Decision to Start

Why did Brazil decide, after years of considering the military uses of nuclear power, to proceed down the path of a militarized program? The realization that Brazil would not acquire full control of the fuel cycle with German assistance alone prompted the National Security Council to discuss military options, but there would have been other possible courses of action to take that would not have necessitated military involvement. If the Brazilian government had been interested only in a civilian nuclear energy program, simply accepting safeguards on imported technology would have solved the problem. There were other reasons to pursue a clandestine nuclear program.

Prestige was also likely a factor in the Brazilian decision. A common theme among countries that sought nuclear weapons after the initial five nuclear powers – the United States, United Kingdom, Russia, France, and China – had acquired them is of a "second tier"

[19] Reiss 1995.
[20] Explanatory Memorandum of the National Security Council no. 011/85 of 21 February 1985, accessed via the Wilson Center at http://digitalarchive.wilsoncenter.org/document/116917

country striving to gain access to the "first tier" and claim or regain prominence on the world stage. Brazil was determined to modernize.[21] A driving goal of the government was to acquire the entire nuclear fuel cycle and thus gain independence from foreign nuclear suppliers and their discriminatory, restrictive policies on less advanced states. The work of the United States to prevent Brazil from achieving this goal only confirmed Brazil's rationale for pursuing it.

Brazil had not experienced any notable or significant change in its security environment. If anything, Brazil's security was improving in 1979 as promising negotiations were conducted with Argentina over a longstanding dispute: the use of the rivers of the Rio de la Plata Basin, shared by both countries, for hydroelectricity. The Treaty of the Rio de la Plata was signed by Brazil, Argentina, and Paraguay in October.[22] Although Brazilian intelligence was aware of Argentina's nuclear program, the two countries were not embroiled in an arms race, and neither country saw the other as a serious military threat.[23]

But while Brazil did not face a serious or imminent security threat, it was engaged in a nuclear strategic rivalry with Argentina. States involved in strategic rivalries see each other as competitors. They may not be engaged in actual militarized disputes, but each believes the potential exists for threats, coming from the rival, that could develop into conflicts.[24] This perception shapes the decision making environment. The Brazilian government's expectation of potential threat from Argentina was much more alarming once Argentina began its nuclear weapons program. Brazil did not need to believe that

[21] Kassenova 2014, Reiss 1995.
[22] Leventhal and Tanzer 1992.
[23] Kassenova 2014, 22.
[24] Colaresi et al 2007. See Chapter 2 for more on strategic rivalry.

Argentine officials would ever actually authorize a nuclear strike against Rio de Janiero or São Paulo. The government may have been concerned that possessing nuclear weapons would embolden Argentina's military to pursue decades- and even centuries-old interests that would threaten Brazil's borders. Having a nuclear strategic rival was powerful motivation for pursuing nuclear weapons.

From a practical standpoint, by the late 1970s, Brazil's civilian nuclear program was two decades old. The risk of starting a militarized nuclear program is higher for countries with nuclear reactor experience (see Chapter 2). Brazil had not only been operating reactors since 1956, it had built its own research reactor in the 1960s. The Brazilian nuclear establishment had accumulated years of experience with nuclear technology and processes. It was far easier, and less costly, for the Brazilian military to begin pursuing its own parallel nuclear program utilizing existing knowledge, expertise, and technology than it would have been to create an entire program from a baseline of no experience.

Brazil's initial nuclear program was clearly peaceful at the outset, with notions of future military uses for the technology relegated to speculation and conjecture. But over time, Brazil's slow slide toward a military program was certainly aided by the civilian experience. Finally, when the National Security Council, the military, and the president were discussing whether Brazil should pursue military applications of nuclear energy, the existing civilian program would have provided the confidence and evidence that such an endeavor could be carried out, paving the way for an affirmative decision to be made.

The Path and Pace of the Nuclear Program

For the first few years after Brazil's parallel program began in 1978-1979, each branch of the military pursued its projects, and CNEN coordinated and supported those efforts. As a result, the projects were not kept separate, but overlapped at times as the branches worked together under CNEN's coordinating authority.[25] CNEN had been strengthened by presidential decree one month after the formal authorization of the parallel program. The decree removed the Nuclear Engineering Institute and the Radiological Protection and Dosimetry Institute (the latter institute was responsible for health and safety for nuclear project workers) from Nuclebrás, the state nuclear energy corporation, and transferred them to CNEN.[26]

CNEN, which had been created by presidential decree in 1956 and placed under the authority of the president, was codified into law in 1962 by an act of parliament, and a subsequent act in 1974 augmented CNEN's authority as a nuclear agency. The 1974 legislation clarified that CNEN would have the authority to, among other things, conduct policy planning and control nuclear installations. The act also clarified that Nuclebrás would implement CNEN policies.[27]

CNEN was, structurally, an independent agency, operating outside of presidential purview.[28] There was no parliamentary oversight of the agency. But the agency's ability to influence the executive, bolstered by its independence, was mitigated by a hierarchical chain of command. The head of CNEN reported to the Minister of Mines and Energy, not the president.

[25] Reiss 1995.
[26] Decree No. 80 783 of 26 July 1979.
[27] Act No. 6,189 of 1974.
[28] Reiss 1995.

Although direct access to the executive would have increased CNEN's potential influence, its high level of independence created the circumstances that allowed CNEN leadership to exercise power. In 1982, Rex Nazaré Alves became the new head of CNEN and "energized" the parallel program.[29] Nazaré Alves had close ties with the military and supported their nuclear mission. Operating as the head of an independent agency coordinating the nuclear weapons program, he worked with his military partners to advance the program. As each branch of the armed services in Brazil had its own ministry, civilian oversight was minimal.[30] Together, CNEN and the military operated with a great deal of independence.

In 1983, Brazil's nuclear strategic rival, Argentina, announced that it had produced enriched uranium. Later that same year, Brazil's parallel program accelerated its pace, working in particular on enrichment, a fast breeder reactor, and on a compact nuclear reactor for powering submarines.[31] Some have speculated that the increased interest in nuclear marine propulsion stemmed from observing the UK's nuclear submarines, displayed during the Malvinas/Falklands war with Argentina the previous year.[32] Others believe this would have been a rationale given to justify a program the Navy was already invested in; the Navy's nuclear submarine program had already begun before the Falklands/Malvinas War occurred.[33] It seems likely that CNEN and the military were able to pursue their parochial interests by leveraging concern about Argentina into the advancement of the parallel program.

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[29] Ibid.
[30] Ibid.
[31] Leventhal and Tanzer 1992.
[32] Ibid.
[33] Kassenova 2014.

In 1985, with the end of the military regime, information about the parallel program was revealed. An official review of the nuclear program was conducted, and a struggle over the future of Brazilian nuclear policy began. The commission was in favor of continuing the parallel program, particularly the enrichment activities.[34] But the commission proposed the division of CNEN into two new agencies, which would be placed under the control of the Ministry of Mines and Energy. Nazaré Alves used his military ties and support to obstruct the plan. In fact, he managed to strengthen CNEN in the process, gaining more power for the agency and transferring its jurisdiction to the presidency.[35][36] By reporting directly to the president, CNEN had secured a greater opportunity to influence him.

A reorganization took place in 1988 that brought even more research facilities under CNEN's supervision.[37] CNEN held onto its power and influence, working with military supports to succeed in keeping an anti-nuclear weapons measure out of the Constitution in 1988.[38] But by this point in the transition to civilian rule, CNEN's influence was being used to play defense, not offense: Nazaré Alves was no longer working to take great steps to move the program forward, but instead used his power to ensure the continuity of CNEN and the parallel program and to protect it from those who wanted to tear it down.

CNEN's ability to pursue its own agenda was enhanced by the extreme secrecy surrounding the parallel program. This strict secrecy was established to protect the parallel program from international restrictions as well as from domestic opposition.[39] The Navy's

[34] Barletta 1997.
[35] *Ibid*, 22-23.
[36] This was formalized in a presidential decree on 7 August 1986,
[37] Barletta 1997, 23.
[38] *Ibid*, 24.
[39] Barletta 1997.

program, which was the most ambitious, was so secret that only four-star admirals were permitted access to all of the project details.[40] This high level of secrecy allowed the program to operate with more independence. The clandestine nature of the program "proved beneficial to internal PATN coalition formation and maintenance, as civilian advocates of technological autonomy were unaware of the support for atomic weapons development among some military sectors."[41]

Civil-Military Relations

Unsurprisingly, Brazil's government was highly militarized during this period through 1984-85, when the process of liberalization began. The military enjoyed a high level of independence and autonomy prior to 1984, and was able to exert pressure on political decisions.[42] Because the Navy, Army, and Air Force each were governed by their own ministries, rather than by a single ministry of defense, civilian oversight of the military was weak.[43] Even after the transition to civilian rule, however, and despite success in the effort to exert more civilian control over nuclear affairs, formal and informal military influence continued to play a significant role.

During the military regime, military leaders were quite effective in pursing their parochial organizational interests. But the military did not appear to be interested in the overall advancement of military nuclear science and technology. Each branch pursued its own program; the coordination and cooperation came at the behest of CNEN. The Navy was most interested in enrichment and submarines; the Army in enrichment and specifically in

[40] Kassenova 2014, 23.
[41] Barletta 1997, 20.
[42] Leventhal and Tanzer 1992.
[43] Reiss 1995.

plutonium production; the Air Force in enrichment and explosives.[44] Military leaders did not press to accelerate the parallel program nor create a grand vision for the future of a unified militarized program. Each branch was content to pursue its own interests under the auspices of CNEN.

The Brazilian military also appeared to recognize that nuclear weapons would not actually be useable in war, and thus were content to continue with the parallel program in its various forms without needing to accelerate the program toward imminent acquisition of a nuclear bomb. General Danilo Venturini, former chief of the National Security Council and close advisor to President João Figueiredo, personally viewed nuclear weapons as political rather than military tools, meant to "impress" but devoid of "military objectives."[45]

Military interests in Brazil were parochial and not national. Each branch chose to pursue its own program, receiving its own stream of funding and carving out its own niche of nuclear research and development. Compared to the typical approach present in other countries of combining national resources and effort into a unified program, the parallel program in Brazil was designed and carried out based on the interests of the military, and not what would be best for the country overall.

National Economy

In the 1980s, the Brazilian economy declined, which had an effect on the implementation of Brazil's nuclear plans. Some work was delayed or indefinitely

[44] The Air Force's Solimoes Project included the construction of at least one hole, about 280 meters deep, with concrete and lead-lined underground galleries, for what was most likely nuclear weapons testing purposes. When the secret site was discovered, amidst domestic and international outrage, Brazil's government claimed that the hole(s) were for mineral exploration, while the Air Force averred that it/they were to be used for testing equipment for an aerospace capability. From Reiss 1995, 51.
[45] Barletta 1997, 16, and footnote 17.

postponed.[46] Brazil canceled plans to purchase more nuclear technology from West Germany.[47] But the struggling economy did not lead to a decision to change the direction of the Brazilian nuclear effort.

The parallel program's perseverance even in the face of severe economic conditions is an example of the lengths governments may go to in order to pursue nuclear weapons. The National Security Council, CNEN, and the branches of the Brazilian military provided the funding for the parallel program. When resources became scarce, funds were withdrawn from secret bank accounts kept hidden from congressional oversight.[48] Uranium mining and yellowcake operations began in 1982, an unsafeguarded facility in São Paulo began work converting uranium to UF6 in 1984, Brazil's first power reactor, Angra I, began operating in 1985, and by 1986, the unsafeguarded Itatiaia nuclear plant had started operations.[49] Even in the midst of the downturn, the government chose to continue to allocate increasingly scarce resources to key nuclear projects.

Rivalry with Argentina

The impact on the nuclear program of the strategic rivalry between Brazil and Argentina is still debated. CNEN head Rex Nazaré Alves has claimed that the rivalry did not factor into decision making.[50] Although the 1975 agreement with West Germany, which included the "red flags" of enrichment and reprocessing facilities, alarmed many foreign governments, Buenos Aires was not among them. Despite the fact that, if the agreement was successfully implemented, Brazil would, for the first time, surge ahead of Argentina in

[46] Leventhal and Tanzer 1992.
[47] Reiss 1995.
[48] Barletta 1997, 11-12.
[49] Solingen 1990.
[50] Reiss 1995, Barletta 1997.

terms of nuclear programs, the Argentine government made no critical public statements. Argentina was not unconcerned about this development; the Brazilian-West German partnership provided Argentina with additional motivation to build a uranium enrichment facility.[51]

Yet both civilian and military Argentine officials quietly defended Brazil's sovereign right to obtain fuel cycle technology. Argentina and Brail both fervently opposed international nuclear technology and fuel restrictions, placed by the nuclear states upon nuclear "have-nots." This shared stance promoted cooperation between the two governments on nuclear affairs, smoothing the way to future nuclear collaboration and openness.[52]

Dismantling the Parallel Program

At the end of November1985, President Figueiredo met with Argentina's president, Raúl Alfonsín, to discuss bilateral cooperation on various topics. The resulting Declaration of Iguazú included measures to create cooperation on nuclear affairs, among them the establishment of a joint working group. Rapprochement with Argentina was brought about due to political and practical reasons, and influenced by personal experiences. The two presidents saw a benefit to standing together against the international nonproliferation regime, cooperating with each other to advance their programs. As heads of state of countries undergoing transitions to civilian rule, they had an interest in showing that they would act differently.[53] On a personal level, Figueiredo had spent part of his childhood in

[51] Reiss 1995, 47.
[52] *Ibid,* 53-54.
[53] Ibid.

Argentina during his father's political exile there.[54] Nuclear scientists from the two countries had built personal ties from international conferences, meetings, and time abroad in each other's laboratories. Some Argentine nuclear scientists left when Perónists drove out political dissenters in the 1970s and relocated to Brazil, where they worked for the Brazilian program.[55]

In 1987, Brazilian President José Sarney privately informed Argentina that the Brazilian Navy had enriched uranium, and then announced it to the world.[56] The public announcement of this achievement enabled Brazil to take its place among the world's masters of the nuclear fuel cycle. But it was the last significant accomplishment of the parallel program. In March of 1990, newly elected President Fernando Collor de Melo established strict civilian control over all nuclear activities. He removed CNEN's independent status, placing it under executive control and firing Nazaré Alves.[57] Collor informed the Army, Navy, and Air Force that the parallel program was being dismantled.[58] He renounced Brazil's right to conduct peaceful nuclear explosions and agreed to accept all IAEA safeguards at nuclear facilities.[59]

That summer, Collor staged a photo opportunity to provide the Argentine public, and the world, with a striking image of the end of the program: Photographers captured the president, crisp and clean in a starched white dress shirt and gleaming black shoes,

[54] Kassenova 2014, 25.
[55] Reiss 1995.
[56] Patti 2011, Barletta 1997, Reiss 1995.
[57] Barletta 1997, 27. Collor placed CNEN under the new civilian-staffed Strategic Affairs Secretariat, which replaced the military-dominated state security service.
[58] Reiss 1995.
[59] Ibid.

shoveling material into the holes at the Air Force test site.[60] The physical act of burying the holes (although Collor himself did not finish the task, as the holes were hundreds of meters deep) symbolized the death of the nuclear weapons program.

Conclusion

The history of the Brazilian parallel program illustrates how institutional influence is affected by organizational structure and executive control. Both CNEN and the military had the ability to influence the various presidents who presided during the time the parallel program was in existence, but that influence depended heavily on institutional independence. Throughout the era of the parallel program, CNEN and the military were able to utilize their independence and autonomy to persuade decision makers and thwart unpalatable plans. President Collor recognized this, as is evidenced by the structural bureaucratic control he asserted over CNEN when bringing the parallel program to a close.

The Brazilian military pursued its own interests during the course of the parallel program, with each branch initiating its own particular set of programs. Instead of focusing national resources on a series of objectives to be met in order to accomplish a single national goal, the military embarked on a diffuse series of parochial programs, some redundant, intended to develop nuclear power for various military applications. The military's failure to rally around a single plan for the good of the country was also due to the institutional feature of separate ministries governing each separate branch, and to the military's belief that nuclear weapons were unusable.

[60] Reported, among others, by James Brooke, "Brazil Uncovers Plan by Military to Build Atom Bomb and Stops It," *The New York Times*, October 9, 1990. There is some dispute over whether Collor shoveled concrete or lime into the holes, and over whether the holes were operational, but the intent of producing such a powerful visual image is clear regardless of those details.

The mixed record of rivalry is also present in the Brazilian case. Prior to the start of the parallel program, Argentina's nuclear progress, in the context of the Brazil-Argentina strategic rivalry, most likely provided part of the motivation to pursue nuclear weapons. At the least, the nuclear strategic rivalry would have served as a convincing rationale to justify such a pursuit. It is less clear how that rivalry affected the course the program took once it had been established. However, the end of the strategic rivalry in 1985 paved the way for the deceleration and, finally, the end of the parallel program.

Pakistan

Pakistan's civilian nuclear program began in the mid-1950s. In 1956, a parliamentary act established a nuclear agency to manage the program: the Pakistan Atomic Energy Committee (PAEC). At this early stage, the PAEC operated at relatively low levels of institutional autonomy. As the agency did not have budgetary powers, its leadership had to seek funding, which was not always granted, from the Pakistani government.[61]

The PAEC chairman at the time, Dr. Nazir Ahmad, complained about being held up by "red tape," while the PAEC's counterpart in India appeared to enjoy significant political support.[62] Organizationally, the leadership of the PAEC included various members of other civilian bureaucracies (two federal ministers and two senior government officials), which led to time delays and inefficiencies. Ahmad did not have the status or governmental support needed to override these competing bureaucratic interests.[63] Constitutional and

[61] Kapur 1987, 38.
[62] *Ibid*, 39.
[63] *Ibid*, 42.

political instability further contributed to the weak agency's inability to gain the resources necessary for progress in the nuclear program.[64]

Institutional change came about in 1959, when Dr. I. H. Usmani became the chair of the PAEC. Usmani drafted the Atomic Energy Law, which gave the PAEC autonomous statutory authority, including financial autonomy. The PAEC also began reporting directly to the Pakistani president. As a result, the PAEC was able to operate largely independently and could stave off attempts at interference from those outside the agency. The military remained uninvolved; the Foreign Office tried to insert itself into nuclear affairs but failed.[65]

While the nuclear program remained peaceful for the next twelve years under Usmani's leadership, the institutional freedom that had been established by the Atomic Energy Law would allow the PAEC to affect the pace of the program after the decision to pursue nuclear weapons had been made. In 1971, Zulfikar Ali Bhutto became Pakistan's president. He had held several ministries from the late 1950s and throughout the 1960s that had enabled him to supervise parts of, or at times the entirety of, the nuclear energy program, and he was a firm believer in the necessity of a Pakistani nuclear weapons program.[66] As head of state, he was now in a position to change the nature of the civilian program.[67]

Bhutto had ridden to power on a wave of popular anger with President Yayha Khan, who had just presided over Pakistan's devastating loss to India in the 1971 war that

[64] *Ibid*, 49.
[65] *Ibid*, 50-52.
[66] Spector 1984, 72-73.
[67] Bhutto would create a new constitution in 1973 granting executive power to the prime minister, at which point, he resigned as president and became prime minister.

resulted in Pakistan surrendering its claim to East Pakistan. The territory became the independent state of Bangladesh, and the people of Pakistan, outraged by the defeat, called for new leadership.[68] Bolstering Bhutto's argument for pursuing nuclear weaponry was the conventional force gap between Pakistan and India. India's conventional military capabilities had been growing, relative to Pakistan's capabilities, during the late 1960s, and the two countries' comparative capabilities had reached a very high level of asymmetry.[69]

In January 1972, Bhutto made the decision to start Pakistan's nuclear weapons program.[70] He removed Usmani as head of the PAEC, replacing him with one of his personal friends, nuclear engineer Munir Ahmed Khan, who supported Bhutto's goal to pursue military uses of nuclear energy.[71] Bhutto removed the PAEC from the Ministry of Science and Technology and instructed Khan to report directly to him.[72] Khan was known for maintaining strict secrecy; the situation at PAEC during his tenure was described as being one in which the right hand didn't know what the left was doing.[73] Khan was the sole leader of the PAEC, and he had been appointed without term limits. With its financial autonomy, institutional independence, a high level of secrecy, and direct access to the executive, the PAEC had been handed the potential to wield great influence.

The Path and Pace of the Nuclear Program

[68] Khan 2013, 79.
[69] *Ibid*, 81.
[70] Khan 2013, Wilson 2005, Kapur 1987, among others.
[71] Spector 1984, 72-73.
[72] Khan 2013, 88.
[73] *Ibid*, 99.

The PAEC formed a group in March of 1974 to manufacture a nuclear weapon.[74] In May of 1974, Pakistan's nuclear strategic rival, India, conducted its first nuclear test. While it is certainly true that many in Pakistan were upset by their rival's nuclear progress and eager to speed Pakistan's program along, the available historical evidence does not indicate that Pakistan accelerated its nuclear program in response. Rather, it quickly became clear to the PAEC that the international community's response was going to hinder Pakistan's nuclear projects.

After the Indian test, most of the states that supplied nuclear technology to foreign governments slowed or halted their transfers. Severe restrictions were placed on nuclear exports. PAEC scientists, and Khan, could read the writing on the wall and started to scramble to obtain whatever technology and promised assistance they could before the restrictions got any worse.[75] Years later, Khan himself emphasized how important it was for the PAEC to be financially autonomous and to have direct access to the head of state.[76] Bhutto became informed of the deteriorating situation and decided to accelerate the nuclear weapons program in June 1974.[77]

The next acceleration occurred in 1977, after General Muhammad Zia-ul-Haq came to power in a military coup. In 1976, the nuclear weapons program's centrifuge project was given to A.Q. Khan and named the Engineering Research Laboratories (which would later be renamed Khan Research Laboratories to honor Khan's work). The following year, Zia separated ERL from PAEC.[78] The separation rendered ERL independent from PAEC, and the

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[74] See *Nuclear Black Markets: Pakistan, A.Q. Khan and the Rise of Proliferation Networks*, International Institute for Strategic Studies: London, 2007.
[75] *Ibid*, 100.
[76] Munir Ahmed Khan's speech at Changhi Medal Award Ceremony at PINSTECH Auditorium, 20 March 1999.
[77] Khan 2013, 121.
[78] *Ibid*, see Chapter 7.

two institutions quickly became rivals. Zia accelerated the program, setting Pakistan upon a concerted effort to attain uranium enrichment. To that end, ERL worked on centrifuge technology, and PAEC on reactor technology.[79] From this point forward, the military became involved in Pakistan's nuclear weapons program.

Civil-Military Relations

Despite the fact that the United States had used nuclear weapons in war in 1945, by the late 1960s, the Pakistani military did not possess sound strategic or tactical understanding of nuclear weapons, even to the extent that officers needed to discuss topics such as the importance of not deploying nuclear weapons near one's own soldiers.[80] In 1967, PAEC head Usmani held a sort of seminar in which he described nuclear weaponry to a group of officers. Although the advanced technical details were incomprehensible to non-scientists and bored the officers, once Usmani explained the destructive power of the bomb, the officers snapped out of their ennui and became extremely interested in the topic. Prior to Usmani's lecture, military leadership had primarily been concerned about conventional weaponry and "our little professional matters of the day," according to then-Major Syed Refaqat.[81]

Despite their newfound interest, however, the Pakistani military was not involved in Pakistan's nuclear program until 1977. Military personnel assisted with security, or with building new sites needed for the program, but the military was not involved with policy

[79] Khan 2013, Kapur 1987.
[80] Khan 2013.
[81] *Ibid*, 80.

making and had relatively little influence. The period leading up to the 1977 military coup was characterized by "exclusive" civilian control over the nuclear weapons program.[82]

When General Zia came to power, the military became the dominant force in Pakistani politics and society.[83] The military began exercising control over the nuclear weapons program; Army officers worked closely with A.Q. Khan, and the military began establishing its own authority over certain facilities.[84] For Pakistan's nuclear weapons program, the legacy of Zia's military control would be the consolidation of military authority over civilian authority.

During Benazir Bhutto's tenure as Prime Minister, beginning in 1988 after the death of General Zia and the restoration of civilian government, the military remained highly influential and powerful. Pakistan's military enjoyed a higher level of institutional capacity than the country's struggling democratic institutions; civilian control over the military was low.[85] The military maintained significant control over nuclear decision making, and the Chief of Army Staff, General Aslam Beg, refused to brief Prime Minister Bhutto on the nuclear weapons program during her first visit to Joint Staff headquarters.[86]

The military was able to isolate the civilian Prime Minister from nuclear decision making by limiting her access to information and establishing the Army as the leader in Pakistan's nuclear effort. In 1989, Pakistan successfully tested new short range, surface-to-surface ballistic missiles, which could reach key targets in northern and western India. It was Beg, not Bhutto, who announced the missile tests. U.S. intelligence analysts at the time

[82] Cheema in Born et al, 2010
[83] Kapur 1987.
[84] John 2005, 32.
[85] Spector 1990.
[86] *Ibid*, 45. He also later refused to brief Bhutto's successor, Prime Minister Nawaz Sharif.

described Bhutto as being "unlikely to gain control over nuclear decision-making any time soon."[87]

The military's prominence in nuclear weapons program development did not lead to program acceleration decisions, as the Army focused on possessing a nuclear arsenal rather than on advancing the program. In the late 1980s, the perception that India's military capabilities and nuclear program were growing created domestic pressure for then-Prime Minister Benazir Bhutto to advance Pakistan's nuclear weapons program.[88] No acceleration decision was made. Then in January 1989, key Pakistani leaders met to discuss the path and pace of the nuclear weapons program.

Present at that meeting were President Ghulam Ishaq Khan, Prime Minister Bhutto, and General Beg, who discussed Pakistan's nuclear force. Despite the domestic political response to tensions with India, the leaders agreed that Pakistan possessed a credible deterrent nuclear force and thus did not need to maintain the status quo pace of the nuclear program. Instead, they decided to, in Beg's words, "temporarily put a restraint on [the] effort."[89] Militaries think in terms of capabilities. Beg believed that Pakistan already had a sufficient nuclear force for its purposes, and thus, using scare resources to improve conventional forces was preferable to investing further in a nuclear weapons program that had, in the eyes of the Army, already achieved its most critical goal.

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[87] CIA Near East and South Asia Review, "Prime Minister Bhutto and the Pakistani Nuclear Issue," from May 5, 1989. An excerpt follows: "PM Benazir Bhutto's influence is sharply circumscribed by the military's firm control over nuclear decision-making and strong commitment to a nuclear weapons program. Moreover, President Ghulam Ishaq Khan gives full support to the military's dominance and direction of nuclear policy. Although Bhutto's access and leverage on nuclear issues have increased since she assumed office last December, she is unlikely to gain control over nuclear decision-making anytime soon… Prime Minister Bhutto agreed not to interfere with Pakistan's nuclear policies as one of several conditions levied by the Army on her in exchange for military support for her becoming Prime Minister."

[88] Spector 1990, 107.

[89] Cheema 2010, 199.

A coup in 1999 brought Pakistan back under direct military control. Under General Pervez Musharraf, who came to power as president in 2001, the institutional structure of the nuclear weapons program became more militarized. Musharraf was, like the military leaders he replaced, "vehemently opposed" to civilian involvement with military affairs.[90] The previous year, an organization called the National Command Authority (NCA) had been established to supervise nuclear weapons research and development. Musharraf had inserted himself as its chair, and continued in that role after claiming the Pakistani presidency.[91]

The NCA, comprised of powerful civilian and military officials, including the Director-General (who is a military general) of the Strategic Plans Division (SPD) and the Commanders of the Army, Air Force, and Navy, had become Pakistan's main decision-making body.[92] From 2000-2007, the head of the NCA was a military official. The SPD was given the authority to oversee the operations of PAEC and KRL, and a 2007 ordinance established by Musharraf strengthened the power of the NCA and military-run SPD, further institutionalizing the military's strong control over the system.[93]

The military's 1998 Strategic Policy Review held the preservation of Pakistan's nuclear capability as the state's chief national security interest.[94] In other words, the military indicated that the *protection of the nuclear weapons themselves* was a national objective. Militaries tend to place great value on the means of conducting warfare, sometimes privileging the means over the outcomes the means are intended to obtain.[95]

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[90] Khan 2013, 308.
[91] Kerr and Nikitin 2012.
[92] Medalia 2011.
[93] Kerr and Nikitin 2012.
[94] Khan 2013, 308.
[95] Sagan 2009, 238,

What is the purpose of a nuclear arsenal? As enormously powerful weapons, nuclear weapons are regarded as the means to protect a state. Yet they are also objects of extremely high value. Nuclear weapons are costly to develop, symbols of a nation's military and scientific prowess, and provide a deterrent against nuclear attack. The Pakistani military views the loss of these weapons, whether by use or by destruction at the hands of a foreign power, as a threat to national security.

As the Musharraf regime further diminished civilian control over the military, the attitude of Pakistan's military toward nuclear weapons was exhibited in several of Musharraf's official state speeches. Musharraf frequently referred to Pakistan's nuclear weapons as the nation's "strategic assets" – an arsenal of critical value and importance that must itself be protected. In a 2001 speech, Musharraf stated: "Pakistan's armed forces and every Pakistani citizen is ready to offer any sacrifice in order to defend Pakistan and secure its strategic assets [nuclear weapons]."[96] Not only the military, but also the Pakistani people, are charged with protecting these weapons. Indeed, in December 2003, Musharraf identified the weapons program as paramount among Pakistan's national interests, stating, "only a traitor would think of rolling back."[97]

Rivalry with India

Pakistan's ongoing rivalry with India drives much of the government's security-based decision making. Prior to the start of either country's nuclear weapons program, the perceived Indian threat in the mid-1950s was used by the Pakistani military to gain

[96] Pervez Musharraf, "Address to People of Pakistan," *Presidential Speeches*, Sept 19, 2001, quoted in Sagan 2009, 238.
[97] Sagan 2009, 239.

popular and financial support for expanding conventional capabilities, and the United States supported Pakistan in this endeavor.[98]

One can identify instances when Pakistan made a nuclear weapons program decision not long after a change in the balance of power between Pakistan and India. Attributing security concerns as the cause of these decisions is often part of the story, but focusing on security concerns alone ignores the other causal factors. The 1972 decision to start a nuclear weapons program was clearly a product of the security environment. While Bhutto had been trying to convince Pakistani leadership to start such a program for years, Pakistan's devastating defeat in the 1971 Indo-Pakistani War brought Bhutto to power, justified his start decision, and rallied internal supporters.

But while some security events may have prompted a change in nuclear program pace, many other security events that have taken place in Pakistan's history did not bring about change. These non-catalyzing events include conflicts in the context of the Indo-Pakistani rivalry, and those in which Pakistan was clearly on the losing side. In 1984, for example, India captured the Siachen Glacier in disputed northern Kashmir. Pakistan tried, unsuccessfully, to reclaim that land in 1985 and 1995. In 1986 and 1987, India conducted major military exercises, called Operation Brasstacks, which were viewed by Pakistan as a threat to national security. The Pakistani military responded by counter-mobilizing and preparing for conflict.[99] None of these conflicts or near-conflicts caused Pakistan to change the pace of its nuclear weapons program.

[98] Kapur 1987, 43. Also at this time, United States was involved in offering civilian nuclear assistance to Pakistan.
[99] Khan 2013, 222.

In 1998, Pakistan conducted nuclear fission tests, effectively declaring itself a nuclear weapons power. The tests took place two weeks after India tested its own nuclear weapons and were a clear response to India's declaration of its nuclear status.[100] What is notable is that Pakistan did *not* respond to India's tests by accelerating its nuclear program. In fact, a decision to change the pace of Pakistan's program did not come for ten more years. Pakistan's in-kind response is a clear example of matching behavior within a rivalry. While Pakistan felt compelled to prove its nuclear status was equal to its rivals, it did not seize the opportunity to advance its program.

The 1999 Kargil conflict is yet another reason to discount pure security explanations for nuclear weapons program activity. Pakistani forces crossed into India-held territory in Jammu-Kashmir. India attempted to repel Pakistani troops with a ground assault, and then launched an air campaign. Hundreds of soldiers on both sides were killed. Finally, as India's position grew stronger and Pakistan lost ground, Pakistan withdrew from the conflict.[101] This two month-long conflict is of particular interest to nuclear weapons scholars because it is an example of a militarized dispute between nuclear rivals that was fought entirely with conventional, not nuclear, weapons.

After Pakistan's unsuccessful two months in Kargil, why did Pakistan's military government not choose to accelerate the nuclear weapons program? Why did the government not respond to a loss to a declared nuclear rival by changing the pace of nuclear development? During the dispute, Pakistani military officers had believed that their nuclear weapons would prevent an Indian response. The civilian leaders, on the other

[100] Cheema 2010, 200; among others; there is a broad consensus on this point.
[101] Kapur 2003.

hand, feared an Indian attack and nuclear escalation.[102] The military had been certain that India would not risk war with a nuclear state; they were proven wrong. Nuclear weapons had not rendered Pakistan untouchable. After the conflict, the military regime sought not to accelerate the nuclear weapons program, but instead focused on means: building up their existing conventional and nuclear capabilities.[103]

Pakistan decided to accelerate its nuclear program in 2009. This was not due to increased security threats to the state, but to a new threat to the nuclear weapons program itself. In April of that year, U.S. President Barack Obama delivered what became known as the Prague speech, in which he pledged to restart work toward a fissile material cut-off treaty. If such an effort were to be successful, there would be new restrictions on fissile material production.

Pakistan responded by accelerating its uranium enrichment program and the construction of reactors to be used for producing weapons-grade plutonium.[104] Increasing production would allow Pakistan to stockpile fissile material in anticipation of a future international prohibition.[105] This response recalls a similar decision in 1974, when PAEC scientists realized the coming consequences of international export restrictions and sought to protect the program by increasing its pace. Once again, Pakistan acted very quickly to protect its program. This response was in the interests both of Pakistan's nuclear bureaucracy, which supported program advancement, and the military, which viewed nuclear weapons as objects to be protected.

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[102] Sagan 2009, 231.
[103] Khan 2013.
[104] Uranium and plutonium production plans reported in *The New York Times* by Thom Shanker and David E. Sanger, "Pakistan is Rapidly Adding Nuclear Arms, U.S. Says," May 17, 2009.
[105] That Pakistan's acceleration was a response to the Prague speech was articulated by Ashley Tellis in an interview reported by Praveen Swami in *The Telegraph* on October 10, 2010.

Conclusion

Pakistan's nuclear weapons program has always existed in the context of the Indo-Pakistani rivalry. Pakistan's decision to quickly respond to India's 1998 nuclear test with its own similar test is only one example of how the two states view each other as direct competitors. Their strategic rivalry fits the "stream of conflict" conceptualization used by Colaresi, Rasler, and Thompson (2007); the rivalry is defined not by distinct security events, but by a general perception of the rival's intentions.[106]

Over the decades, the Indo-Pakistani rivalry has waxed and waned. There have been periods of high tension that spill over into conflict, and periods where the two states attempt rapprochement. The various high-conflict periods did not, however, cause the Pakistani government to accelerate its nuclear development. The trajectory of the rivalry has not been the proximate cause of Pakistani nuclear weapons program pace decisions.

The Pakistani case is particularly interesting because it combines two opposing forces on the likelihood of program acceleration: a highly independent nuclear bureaucracy and weak, and at times absent, civilian control of the military.

In the first years of Pakistan's nuclear weapons program, the influence of the highly autonomous PAEC creates opportunities for quick responses to events. Prior to the 1974 Indian PNE (peaceful nuclear explosion), the PAEC had already moved toward work on constructing a nuclear bomb. In the aftermath of the PNE, when nuclear suppliers around the world began to talk about export restrictions, the Pakistani government could easily have decided to temporarily suspend the program until new avenues for procuring and

[106] See Chapter 2 for a discussion of strategic rivalry.

developing material and equipment could be researched. However, the PAEC argued for expanding the program immediately to develop as much as possible before international restrictions would limit their progress, and the decision to accelerate was made.

The nuclear weapons program was controlled exclusively by civilian authorities until the 1977 military coup. The military acted to exclude civilians from decision making. Even after the period of military rule, civilian institutions were so much less developed than military institutions that the military was still able to isolate civilian leaders from nuclear weapons policy. Twelve years after the coup, the military, in conjunction with civilian leaders, proposed decelerating the nuclear program, as officers felt a credible deterrent had been established. Pakistan's military had achieved its goal of building a nuclear arsenal and did not wish to advance the program further.

The military remained focused on developing conventional capabilities instead of the nuclear program, and for good reason: conventional capabilities are the main reason India has won every militarized conflict with Pakistan that has not ended in a stalemate. Advancing the nuclear program at the expense of conventional weapons and equipment was not a priority for the Pakistani military. With a credible deterrent in place, the military turned its focus to protecting the nuclear arsenal, identifying the weapons themselves as a vital national security interest. Since Pakistan's return to civilian rule in 2008, the nuclear weapons program has been reported to be developing at a faster pace.[107]

United States: 1939-1950

[107] Albright and Brannan 2011, Kristensen and Norris 2011.

The Decision to Start

In 1939, top scientists around the world were engaged in theoretical work on nuclear fission. Fission represented the cutting edge of physics since the 1938 discovery that bombarding the uranium atom with neutrons cause the nucleus to split, producing much lighter chemical elements. Scientists quickly began to understand that the enormous energy produced by splitting uranium nuclei could be used in war. In August of 1939, Albert Einstein drafted a letter to President Franklin D. Roosevelt that explained the potential for the development of "extremely powerful bombs of a new type" and speculated that Germany's capture of Czechoslovakian uranium mines indicated that Hitler was already pursuing a fission bomb.[108]

Einstein's letter, explained to the president by Dr. Alexander Sachs, a former member of the Roosevelt administration, spurred Roosevelt to respond. He directed his aide, General Edwin M. Watson, to take action; Watson promptly formed a committee to discuss the military potential of nuclear fission. The committee consisted of Dr. Lyman J. Briggs, who at the time directed the Bureau of Standards, "the nation's physics laboratory;" Army Lieutenant Colonel Keith F. Adamson; and Naval Commander Gilbert C. Hoover.[109] The two high-ranking military officers were both experts on explosives. Briggs then set up the inaugural meeting of the Advisory Committee on uranium (later referred to as the Uranium Committee), which was comprised of those same individuals plus a coterie of top nuclear scientists.[110]

[108] Letter from Albert Einstein to President Franklin D. Roosevelt, 2 August 1939.
[109] Rhodes 1986, 314-315.
[110] Ibid.

Lt. Col. Adamson, according to participant Dr. Leo Szilard, became angry upon hearing that the scientists needed several thousand dollars to buy graphite (which would slow down the uranium neutrons enough to maintain a nuclear chain reaction). Adamson argued that a new weapon would be impractical for use in the current war (in which the United States was not yet involved), maintaining that one can only know whether a new weapon is useful after it has been tested on the battlefields of two wars.[111] Adamson's reaction exemplifies the tendency of militaries to privilege existing weapons systems: As an Army officer, he knew how to assess the power and usability of conventional ordnance in war. The prospect of diverting funds away from known weaponry to experiments that might never result in success – and to do so during wartime – angered him. The interests of the Army as an organization, and of the country, led him to oppose fission research.

Although Adamson's viewpoint did not govern the committee, neither did the views of the scientists win the day. For more than two years, there was a great deal of uncertainty about whether to proceed down the path to nuclear weapons. Many in government did not believe that nuclear fission was possible. Reports that Germany was working to develop a nuclear bomb were met with skepticism from numerous scientists and non-scientists alike.[112] It took months, and a request from Watson, just to get Briggs to transfer the funds for the purchase of graphite that Adamson had fought against.[113]

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[111] *Ibid*, 317.

[112] This skepticism was not unique to those involved with the American effort. British nuclear scientists were initially doubtful that nuclear fission would have military significance. Henry Tizard, a leader in the British war effort, particularly regarding the development of radar, openly criticized the French for their concern about German nuclear research, declaring that, in his opinion, there was only a remote chance of a military application for the science. See Rhodes 1986, 330. In Russia, Stalin was also told of the likelihood of a German program, and of research into nuclear fission for military purposes generally. He did not take these reports seriously until 1942. See Holloway 1994.

[113] Rhodes 1986, 331.

Because the science of nuclear fission was so difficult to understand, Roosevelt's top officials found it impossible to know what recommendation to make to the president on the course the United States should set. National Defense Research Committee (NDRC) head Vannevar Bush formed a review committee comprised of experienced physicists to evaluate the science and offer recommendations.[114] The review committee met in April and May of 1941 and heard from Uranium Committee members and British scientists. They delivered a report on May 17 in which they recommended that the United States take the lead in nuclear fission research and provide the scientists with the money they needed to conduct their experiments. Bush read the report and proposed a "new umbrella agency with wide authority over all government science in the service of war," the Office of Scientific Research and Development (OSRD). Further consolidating his power, Bush would direct it and report personally to President Roosevelt.[115]

Doubt, and the immediate perils of war, continued to postpone a decision to start a nuclear weapons program. While the United States still had not entered World War II, it was becoming clear to American officials that Nazi Germany posed a worldwide threat. But because nuclear weapons existed in theory only, many were hesitant to allocate resources to an experimental program that might be better used to manufacture tried and tested weaponry and military equipment. James B. Conant, a renowned chemist and the former president of Harvard, who was appointed by Bush to fill his old position as head of the NDRC, wrote in 1941:

> "To me, the defense of the free world was in such a dangerous state that only efforts which were likely to yield results within a matter of months . . . were worthy of serious consideration . . .

[114] *Ibid*, 362.
[115] *Ibid*, 365.

> [Physicists]talked in excited tones about the discovery of a new world in which power from a uranium reactor would revolutionize our industrialized society. These fancies left me cold. I suggested that until Nazi Germany was defeated all our energies should be concentrated on one immediate objective."[116]

Like Lt. Col. Adamson, civilian leaders, facing the prospect of war, acted in what they felt to be the best interests of the country and refrained from starting down a path that would require great expense and years of work before resulting in a usable weapon.

However, evidence of success was on the horizon. London had authorized work toward a fission bomb, and the MAUD Committee (which oversaw the program at that time) was drafting a formal report on the scientists' progress that would be shared with the United States. But when the report was sent to Briggs, the physicist at the head of the Uranium Committee, he concealed it in his office safe and told nothing to the other members of the committee. Finally, in the fall, the program "changed direction," according to Conant, because of Australian physicist Dr. Mark Oliphant. Oliphant, who served on the MAUD Committee, was astonished that the Washington was ignoring the committee's findings. He flew first to the east coast, then to the west, and attempted to persuade scientists and officials to concentrate every effort on the bomb. The Uranium Committee, having been kept entirely out of the loop by Briggs, was surprised to hear Oliphant's tidings of successful experiments, as were the other scientists he spoke to.[117] (372-373)

Authority over the nuclear question was still too diffuse to bring quick results. It was unclear who needed to be persuaded, because it was unclear who had the ultimate authority to act. Eventually, through a long chain of scientists and officials from Berkeley to Washington to Chicago, Conant became convinced of the high probability of successfully

[116] *Ibid*, 367.
[117] *Ibid*, 372-373.

constructing a nuclear bomb.[118] On October 9, 1941, about a week after Conant received the MAUD report, Bush carried it directly to Roosevelt.[119] The attack on Pearl Harbor would not be carried out for nearly two more months.

The president authorized the program and established his own personal authority over it. Key policy makers would report to Roosevelt. Scientists tapped to join the project could decline, but if they accepted, they would not have authority over policy. Those who did not want to contribute to the pursuit of fission weaponry stayed out.[120]

Why did the government of the United States decide to start a nuclear weapons program? The scientists working to convince the government of the urgency of beginning a program were certainly aware of the dangers of a future German nuclear bomb. They realized that someone, somewhere, would eventually work out how to harness the power of fission for military use, and they feared what would come to pass if Nazi Germany achieved this feat before the United States.[121] In many cases, these fears were based on personal experiences that the U.S. officials, who seemed to be dragging their feet, did not share. Several of the top scientists working on fission had been born in Europe and had family still there, some of whom were Jewish and faced persecution. Some had fled Europe as the Nazi threat expanded. One such scientist was Enrico Fermi, who would later lead the team that achieved the first nuclear chain reaction at the University of Chicago. Fermi had escaped from Italy in 1938 with his wife, who was Jewish. They needed liquid assets to

[118] *Ibid*, 374-377.
[119] *Ibid*, 377.
[120] *Ibid*, 378-9.
[121] *Ibid*, 379.

arrange their journey without raising suspicion, and so they used the money Fermi had just been awarded as a Nobel Prize winner.[122]

Roosevelt was thinking beyond the present war – a war in which the United States was not yet militarily involved. He recognized that the use of nuclear energy would be "a military development that would change the political organization of the world."[123] Roosevelt and Bush were both uninterested in assessing German progress toward the bomb. They were aware of the German program, but the decision to start a nuclear weapons program was not made because of it. The evidence that fission bombs would actually work, and deliver what the scientists had promised, was what mattered to men who had to make hard choices about the use of scarce resources. Roosevelt had heard what his advisors had relayed about the decisive power expected from these astonishingly destructive weapons, and he had considered the long-term, strategic impact of nuclear bombs.[124]

Finally, it is worth noting that there is no "smoking gun" document recording Roosevelt's decision to authorize a nuclear weapons program. The account of his decision relies on witnesses' descriptions of the October meeting, and on the expression "OK," scrawled by Roosevelt weeks later on a piece of note paper attached to a report, which Bush had given Roosevelt to peruse, on the promise of uranium bombs.[125] The lack of a clear authorizing document is common across the set of states that have pursued nuclear weapons.

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[122] *Ibid*, 248-250.
[123] *Ibid*, 379.
[124] *Ibid*, 405.
[125] *Ibid*, 387-388.

The Path and Pace of the Nuclear Program

Although the formal decision to start a state nuclear weapons program had been made, authority was still so diffuse that progress was impeded by bureaucratic obstacles. There was no sole authority, and scientists neither had access to everything they needed for their work nor a clear leader to petition. The project was divided between the Army and Vannevar Bush's agency, the OSRD. The Army was uninterested in prioritizing the nuclear project ahead of its others. In an effort to clarify and consolidate authority, Bush proposed that a new committee be formed to lead the project.[126]

His recommendation, which he discussed with a general associated with the Army side of the effort, resulted in an even more autonomous authority: A single Army officer would head what came to be known as the Manhattan Project. The general Bush spoke to, Brehon Somervell, selected Colonel Leslie Groves to command the project and receive a promotion to Brigadier General.[127] While initially reluctant to accept the assignment, Groves found the mismanaged nuclear weapons program to be in disarray, and he promptly took charge, wielding all the authority he had been given. The general would order things done that had been delayed for months, and they would happen immediately.[128]

Groves's knack for management included an understanding of institutional characteristics. When Secretary of State Henry Stimson proposed a nine-person committee to supervise the Manhattan Project, Groves insisted on three, and won.[129] As commander of the project, he had no term limitations and no co-chair with whom to share power. Even

[126] *Ibid*, 424-425.
[127] *Ibid*, 424-425.
[128] *Ibid*, 426-428.
[129] *Ibid*, 428.

the director of the project, J. Robert Oppenheimer, had to submit a request to Groves if he wanted to fire a scientist.[130]

A career Army officer, Groves had just finished leading the effort to build the Pentagon. He well understood the benefits secrecy would bring to a project that needed to be carried out quickly, with as little interference as possible. Soon after taking command, Groves set out to build what would essentially become a separate state within the United States. A remote part of New Mexico, Los Alamos, was chosen for the site of the national laboratory that would be the epicenter of the nuclear weapons program. The Army Corps of Engineers quickly erected family housing and scientific facilities, along with wire fencing surrounding the complex. Groves imposed security measures intended to isolate the Manhattan Project employees and their families: wire fencing surrounded the complex; pass controls when someone wished to leave; and the near-total elimination of telephones. Even the scientists' spouses, trapped at Los Alamos while their husbands worked 6-day weeks, weren't permitted to know what all of the work was for.[131]

This extreme secrecy both protected knowledge of the nuclear project and gave General Groves significant authority. The project was so secret, even Vice President Harry S. Truman knew only of its existence, and nothing further.[132] Richard Rhodes quotes Roosevelt administration official Herbert S. Marks:

> "The Manhattan District . . . was a separate state, with its own airplanes and its own factories and its thousands of secrets. It had a peculiar sovereignty, one that could bring about the end, peacefully or violently, of all other sovereignties."[133]

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[130] *Ibid*, 546.
[131] *Ibid*, 448-460. Oppenheimer agreed that these were necessary measures.
[132] *Ibid*, 614.
[133] *Ibid*, 277.

This separate state was linked to the U.S. government only by the chain of command ending with President Roosevelt. Information about the project reached Roosevelt either directly from General Groves, or from Groves via one of Roosevelt's top aides, such as Secretary of State Henry Stimson.[134] Groves thus had a great deal of influence with the ultimate decision makers, as he controlled both the project and the information that reached the president. He succeeded in setting the pace of the program at maximum speed in the race to be the first to develop a fission bomb.

The first products of this program, a plutonium test bomb, the uranium bomb named "Little Boy" that was dropped on Hiroshima, and the plutonium bomb named "Fat Man" that was dropped on Nagasaki, revealed the horrific power of nuclear weapons. Once World War II had ended, the United States had to decide how to proceed with the nuclear weapons program. After a debate over whether the nuclear weapons program should remain under military command, a new civilian authority was formed to take over the management of America's nuclear weapons program.[135]

The Atomic Energy Act of 1946, which went into effect on the first day of 1947, combined all aspects of nuclear weapons development into one agency: development, production, and control.[136] That agency was named the Atomic Energy Commission (AEC), and was given significant autonomy by Congress.[137] The president appointed the commissioners who headed the agency, and the AEC was granted the authority to hire its

[134] See, for example, 625-626 in Rhodes 1986.
[135] Buck 1983.
[136] Atomic Energy Act of 1946, Public Law 585, August 1, 1946. The physical control of nuclear weapons would later be given to the military.
[137] Buck 1983.

own employees, including scientists, outside of the Civil Service system.[138] Congress did not play a role in nuclear policy at that point in time.[139]

The AEC's influence was constrained, however, by its placement within the executive, and by three advisory committees. The commissioners, led by David E. Lilienthal as chairman, originally planned to commit a significant part of the agency's budget to pursuing peaceful uses of nuclear energy, but they were directed instead to use the majority of their resources on weapons development and production. The mission of the AEC quickly became narrowly defined, and within two years, the agency had begun stockpiling nuclear weapons and weapons technology.[140]

Once the purpose of the AEC had been determined, and its focus became the military use of nuclear energy, interests in nuclear weapons development became entrenched. Disagreement over the best course of research and development emerged among scientists who favored continuing with nuclear fission weapons and those who wanted to begin work on nuclear fusion.[141] Fusion bombs are also known as hydrogen bombs or thermonuclear bombs. When nuclei from light elements – such as hydrogen elements, or two of hydrogen's isotopes, deuterium and tritium – are combined with neutrons and then heated until they collide at extremely high speeds, the amount of energy released is many times that of nuclear fission. Fusing hydrogen into helium, for example, is the source of the sun's energy. Nuclear scientists in the United States nicknamed the hydrogen bomb "the Super."

The incredible energy release from a fusion bomb is vastly more destructive than that of a fission bomb. Many of the nuclear scientists, including those on the AEC's General

[138] *Ibid*, 1.
[139] Born et al 2010.
[140] Buck, 2-3.
[141] Miscamble 1993.

Advisory Committee (GAC), which was chaired by Oppenheimer himself, were opposed to developing thermonuclear weapons because of this; some called the Super "a weapon of genocide."[142] The scientists who advocated for the project, Edward Teller being the most vocal, were frustrated by the AEC's bureaucracy and by their inability to get a clear authorization to proceed, which would bring with it the needed materials and technology.[143]

This internal debate came to a head when the Soviet Union tested its first fission weapon August 29, 1949. Washington quickly began a reevaluation of U.S. nuclear policy and debated the best response. Earlier in the year, plans had already been approved to expand the nuclear weapons program, but the expansion was for fission weapons development and production only. The GAC opposed responding to the Soviet test by pursuing the super; the advisory committee believed that pursuing the development and testing of the Super would divert attention and resources from the planned expansion.[144] Oppenheimer argued that stockpiles were too low to allow nuclear reactors to be diverted away from plutonium production in favor of tritium production.[145] Three of the five AEC commissioners sided with the GAC, agreeing that hydrogen bombs were a danger to humanity.[146] The Joint Chiefs of Staff, wanting to build a better arsenal than Russia's, supported the development of the Super.[147]

President Truman would ultimately decide whether the United States would respond to a nuclear Soviet Union by trying to develop the Super. Access to the president

[142] Miscamble 1993, 301.
[143] Miscamble 1993.
[144] *Ibid*, 299-301.
[145] Gordin 265.
[146] Holloway 1994.
[147] Ibid.

became critically important for those on either side of the issue. The lack of one single authority along the lines of a General Groves meant the decision had to be debated and thus delayed. The AEC's structure, a commission led by several commissioners and advised by three other committees, each comprised of several members, meant that the nuclear program was not represented by a single voice, and the lack of consensus among the various commissioners and advisors produced a jumble of proposals that diluted the program's influence. It took months for a decision to be made.

The division among the AEC scientists and administrators disturbed President Truman. Without a clear recommendation from the nuclear program, he felt unable to make a decision. Truman thus established a committee of three to advise him on the decision: Secretary of State Dean Acheson, AEC chair David Lilienthal, and Secretary of Defense Louis Johnson. The committee was charged with developing a clear recommendation to present to the president.[148] From the start, Johnson supported the development of the Super, Lilienthal opposed it, and Acheson was undecided.[149] But after weeks of deliberation and gathering arguments from all sides, the committee submitted a recommendation to the president to authorize the development of the hydrogen bomb. On January 31, 1950, Truman announced his decision to accelerate the program to develop the Super.[150]

Conclusion

[148] Miscamble 1993, 301-305.
[149] *Ibid*, 305.
[150] Rhodes 1986, 768.

The danger presented by Hitler's expansionism and the start of World War II was perceived as a potential, though not yet direct, threat to U.S. interests when American officials were deliberating whether to start a nuclear weapons program. Yet the security environment did not bring about a quick decision. The decision was made in the context of the understanding that other states would try to develop nuclear weaponry, and that this new technology had the potential to change the world political order.

The decision was nearly *not* made during that fall of 1941, however, because of the lack of oversight of the Uranium Committee. The ability of the head of the committee, Lyman Briggs, to stuff the MAUD report in his office safe, and the fact that others in positions of authority over Briggs had no idea that this report had even arrived, let alone what it said, prevented decision makers from endorsing the project to President Roosevelt. Threat alone was not enough to convince those in power of the utility of starting such a project when resources were scarce and other technologies had already been proven. Although governments had clear evidence of nuclear weapons' effectiveness once news spread of the destruction of Hiroshima and Nagasaki, the essential dilemma of how to allocate resources would plague other state leaders considering whether it would be wise to embark upon such a costly and long-term project.

Once the program had begun, its institutional features, many of which were intentionally designed by General Groves, created a high level of program autonomy that was bolstered by secrecy. That autonomy gave Groves influence over the pace of the program that the diffuse authority of the previous incarnation of the project had lacked. When the AEC was created, the vertical hierarchical structure of the Manhattan Project was replaced by a more horizontal structure, with added committees and added voices, and less

independence. That structure had a clear impact on the timing of the U.S. decision to begin a thermonuclear bomb program, despite the rivalry with the Soviet Union.

Comparing the American debate over the Super to the Russian decision to change its program's focus to the hydrogen bomb reveals two key distinctions. First, while many American scientists and officials were morally opposed to the pursuit of thermonuclear weapons, Russian scientists and officials held no such feelings – or if they did, they did not reveal them. A debate over the ethical considerations of such destructive power never occurred in Russia.[151] Second, the institutional structure of the Russian program did speak with a single voice: L. P. Beria's, the NKVD (state police and espionage) head who was also the chair of the Special Committee on the Atomic Bomb, a committee of only three people that led nuclear weapons policy making. Beria, not the committee, reported directly to Stalin on a weekly basis.[152] There was no parliamentary oversight, no set of advisory committees, no review by the military. The formal decision to accelerate research on the thermonuclear bomb to a "full-scale project" took place in February 1951.[153] There is no indication that the decision was controversial or debated in any way; it was proposed and then accepted. A less influential institutional structure lengthens the time to a decision to accelerate.

[151] Of course, Stalin himself was devoid of moral qualms regarding the hydrogen bomb. While Truman wrote of the horrific nature of fission weapons, he left no personal writings from the period when he was making the decision to authorize the U.S. hydrogen bomb program. See David McCullough, *Truman*, New York: Simon & Schuster, 1993.
[152] Holloway 1994.
[153] Von Hippel 2004, 74.

Conclusion

While each of these case studies is situated in the context of each individual state's particular characteristics and histories, common threads emerge from the narratives. A state's strategic rivals, the relationship between civilian and military structures, and the level of independence of the nuclear bureaucracy affect the path and pace of nuclear weapons programs. High levels of secrecy, opacity stemming from science and technology accessible only to experts, and strong feelings of awe serve to boost the power of experts to influence decision makers.

Civil-military relations influenced program path and pace. In Brazil and Pakistan, more militarized governments made decisions influenced by their own organizational interests, which slowed the pace of their nuclear weapons programs. Each branch of the Brazilian military pursued its own militarized program, which the military regime permitted, and which created a disjointed and plodding path to weaponization. Pakistan's military, when it felt a credible deterrent had been established, proposed a deceleration of the nuclear weapons program, which the weak civilian controlled-regime acceded to. Military leaders focused on conventional capabilities instead, and for good reason; Pakistan's ongoing strategic rivalry with India has taken place in a stream of conflict in which outcomes are generally determined by India's superior conventional strength.

More independent nuclear bureaucracies, with greater access to the executive, were able to hasten the pace of nuclear weapons programs in several instances. Brazil's nuclear agency, CNEN, possessed a high level of institutional independence. The head of CNEN used that autonomy, bolstered by secrecy, to persuade decision makers to support his preferred policies, as well as to suppress undesirable policies. When President Collor took office and

began trying to shut down the parallel program, he made structural bureaucratic changes to CNEN in order to make the agency less autonomous and thus decrease its power. Pakistan's independent nuclear bureaucracy was able to respond quickly to changing circumstances and insert itself into decision making processes; that ability was lost after a military coup that virtually excluded civilian leadership from nuclear weapons policy.

One possible set of differences between an influential agency and an ineffectual one is illustrated in the United States case. When General Groves ran the Manhattan Project, he had no term limits, no co-chair with whom to share power, the authority to fire staff, and, by his own doing, a minimally staffed supervisory committee. He also ran the project under exceptionally high levels of secrecy. But the successor to Groves' Manhattan Project, the AEC, had no single voice speaking for the nuclear agency's interests, and less independence. That structure contributed to the timing of the U.S. decision to develop the hydrogen bomb, slowing the pace at which the program was developing.

Finally, rivalries provided context for the Brazilian and Pakistani nuclear weapons programs, but did not drive program pace in either case. Brazil's nuclear strategic rivalry with Argentina did influence Brasília's decision to start, along with Brazil's nuclear reactor experience. But the rivalry did not have a clear impact on the path of the program after that decision. The strategic rivalry between India and Pakistan, while a fundamental component of both states' foreign and defense policymaking, has not caused Pakistan to accelerate the pace of its nuclear weapons program. The absence of decisions to accelerate during or after many militarized conflicts between the two states is a strong rebuttal to the notion that this rivalry has determined the path of Pakistan's nuclear weapons program.

CHAPTER 6

Conclusion

In this dissertation, I set out to answer two main questions. Why do some states decide to start nuclear weapons programs? And once they start, why and when do they vary the path and pace of their nuclear development? I contribute new theories on civil-military relations and nuclear bureaucracy, and an original data set to address an area of the literature that has not yet been analyzed across all cases: The path and pace of nuclear weapons programs.

In Chapter 2, I used an event history model to identify the conditions under which states are at risk of deciding to start nuclear weapons programs. I grouped the conditions into two categories: opportunity and motivation. I found that elements of both categories put states at greater risk of making a start decision.

Opportunity is defined by a state's capacity to pursue a nuclear weapon program, and is comprised of wealth, energy, materials, and knowledge. Wealth was not found to be a determining factor in making a decision to start. If a state with limited resources desires nuclear weapons strongly enough, leaders may disregard economic constraints and make sacrifices to finance a program.

I found that energy, materials, and knowledge are more important. A nuclear program requires the electrical capacity to operate a nuclear reactor, as well as associated

equipment and facilities, depending on the chosen technological route (e.g. centrifuge cascades for enriching uranium). Only one state has ever made a start decision without first having the electrical capacity needed to run a program.

The material and knowledge-based costs of developing nuclear weapons are significantly lowered if a state has nuclear reactor experience prior to making the decision to pursue nuclear weapons. By operating a peaceful nuclear program, some of the difficulties of starting a weapons program have been attenuated through the accumulation of scientific and technological knowledge, experience, and equipment. In addition, states with nuclear reactors typically already possess other needed measures of capacity, like advanced metallurgical or chemical capabilities. I showed that these states are at greater risk of making a start decision than are states without nuclear reactor experience.

Regarding motivation: Many states have the capability needed to pursue nuclear weapons, but choose not to. A state must also be willing to proceed down the costly and controversial path to the bomb. Three key categories of motivators may drive states to start a nuclear weapons program: Security, domestic political interests, and norms.[1] As the case histories of nuclear weapons-seeking states indicate that each of these motivators has led various states to make the decision to start a program, recent scholarship has used quantitative methods to systematically analyze which motivators affect decision making.[2]

Certain aspects of the security environment affect a state's risk of making a decision to start a nuclear weapons program. Not all security concerns are equal; a threat from a regional rival may motivate a state to build up its military capabilities, while a threat from a relatively weak neighbor may not. Individual events like militarized disputes, or verbal

[1] Sagan 1996.
[2] See in particular Singh and Way 2004, Jo and Gartzke 2007, Fuhrmann 2009, Kroenig 2009, and Bleek 2013.

threats, or the mobilization of military personnel, are easy to identify, in hindsight, as the proximate cause of a decision to start a nuclear weapons program. But some states experienced threats and events for years before making a decision to start, and many other threatened states have never made the decision at all. I therefore sought to determine which elements of the threat environment are influential.

Security events, measured by militarized disputes, were not significant causal factors of a government making a decision to start a nuclear weapons program. Security guarantees provided to a protégée from a nuclear protector also had no identifiable effect on the risk of a start decision.

I found that a conventional military threat to a weaker state, although not as important as previously thought, does have a meaningful impact on increasing the likelihood that the weaker state will decide to start a nuclear weapons program when threat levels are very high. When the asymmetry between a pair of rivals is great – such as a fivefold difference in conventional capabilities – the weaker party is at a substantively greater risk of choosing to turn to nuclear weapons to narrow the gap.

Whether a threat emerges from a nuclear power or non-nuclear power also matters to a state thinking about whether to start its own nuclear program. I found that if a state has a nuclear strategic rival, the probability that the state will start its own nuclear weapons program rises substantially, whether the rival already possesses nuclear weapons or is still only attempting to acquire them. Nuclear weapons seekers put their strategic rivals at greater risk of starting their own programs. In fact, of all the competing explanations tested, a nuclear strategic rivalry rendered the largest substantive impact by far on the risk of pursuing nuclear weapons. Furthermore, its predicted impact was

supported by a very high level of certainty within the event history model; it was consistently the most statistically significant variable across multiple versions of the model.

In Chapters 3 and 4, I presented new theories on the path and pace of nuclear weapons programs. Once a state decides to start a nuclear weapons program, how that program unfolds depends on political decisions made by top leadership. I term the decisions leaders make to change the pace of a nuclear weapons program – whether to speed it up or to slow it down – "pace decisions." Until now, pace decisions have been identified in historical case studies of nuclear weapons-seeking states, but have not been systematically analyzed to identify patterns of decision making.

The quantitative proliferation literature has addressed the following questions: What leads states to desire nuclear weapons? Why do only some pursue nuclear weapons? What is the likelihood of a state starting a nuclear weapons program or acquiring a nuclear bomb? Why do states provide nuclear assistance to help other states acquire nuclear weapons?

What has been missing from the conversation has been the path states take to the bomb. How do programs develop? Why do some proceed quickly, while others proceed slowly? Why do some take steps forward and then steps backward, and then forward again? Other than looking at likelihood of acquisition, scholars have not conducted quantitative investigations of what happens along the path of a nuclear weapons program.

I used two approaches to test my theories of both start and pace decision making: statistical modeling, and case studies. The statistical model used a new and original data set that I created by examining government documents and nuclear program histories. I compiled a complete list of all political decisions to accelerate, decelerate, or stop a nuclear

weapons program that occurred in each country that has ever started such a program. The case studies appeared in Chapter 5 and provided historical context supporting my theories of the risk of making a decision to start a program and the risk of making a decision to accelerate an existing program.

In Chapter 3, I argued that a state's civil-military relations affect the likelihood of a decision being made to accelerate the nuclear weapons program. I found that states with weak or no civilian control of the military are at lower risk of making an acceleration decision. There are certain characteristics that are commonly found in militaries that account for this lower risk.

Militaries strive to minimize civilian interference in military affairs in order to better pursue their preferences. Those militaries that enjoy weak or no civilian oversight are able to have greater influence in nuclear policy, limiting the influence of civilian leaders in nuclear decision making.

Militaries tend to prefer to utilize scare resources to support conventional programs over nuclear programs. This is due to militaries' traditional interests, to their experience in fighting conventional wars, and to their belief that nuclear weapons cannot actually be used in war fighting. Nuclear weapons are perceived by militaries as providing a deterrent against attack, as well as conferring prestige. But they are not viewed as offensive weapons; they are unusable. Because of this, military interests are generally better served by accumulating the weapons themselves to achieve a deterrent force rather than by advancing a program to build more sophisticated unusable weaponry. Militaries think mainly about capabilities, and amassing an arsenal is preferable to investing heavily in development that may or may not result in better weaponry.

Militaries are inwardly focused. A military government must be inward-looking in order to survive, and its resources are used accordingly. This type of military is concerned more with domestic stability and internal politics than with external security threats. Defense policy may be designed with the protection of the regime prioritized over the protection of the nation's security. Militaries with this inward focus do not have great incentive to accelerate nuclear programs, as they primarily need soldiers, tanks, and guns to provide domestic stability. Nuclear weapons, in this scenario, cannot help the military achieve its primary goal, and the military has less incentive to accelerate a nuclear weapons program.

In Chapter 4, I argued that structural, institutional characteristics of a state's nuclear agency affect the likelihood of a decision being made to accelerate the nuclear weapons program. I found that states with more independent nuclear agencies, and whose agencies' structures are protected by more formal legal authority, are at higher risk of making an acceleration decision.

While the head of state has the authority to make a pace decision, he or she does not make that decision in a vacuum. Executives are influenced by security concerns, certainly, but also by the bureaucracies that provide them with the information and policy options executives use to determine what decision to make. Bureaucracies with competing interests try to influence the executive, and some are more influential than others.

Bureaucratic influence is sometimes intangible; a strong affinity or friendship between an agency head and a president or prime minister can contribute to personal influence. But even a key player with ties to the head of state needs to establish institutional structures that allow for bureaucratic influence; programs grow, leaders

change, and the number of people and organizations who can influence the course of the program increases over time.

A more autonomous nuclear agency is more likely to be able to set nuclear policy from the bottom up, according to its own agendas and practices. And the more independent the nuclear agency is from political control, the more freedom the agency has to try to persuade decision makers to follow the agency's preferred policies. The way an agency is structured affects the agency's ability to exercise influence. I divided those structural characteristics into two categories: independence and origin.

I determined a nuclear agency's level of independence by asking three questions: To whom does the nuclear agency report? Does the nuclear agency fall under executive control? And does the government have oversight of the nuclear agency? Agencies reporting directly to the head of state, that are outside of executive control and thus have a greater capacity to develop and promote their own preferences, and that fall outside of government oversight have the greatest ability to exert influence over the head of state.

A nuclear agency's origin is important because the means by which it is created (or re-created in subsequent reorganizations) can affect how insulated it is from the rest of the government. An agency protected by formal legal authority is more difficult for heads of state to weaken or eliminate. Such agencies are able to exercise more influence on the executive because their survival in the state bureaucracy is relatively secure. An agency with formal legal codification is more likely to have the authority to insert itself into state policy making and better pursue its preferences.

These institutional characteristics particularly affect influence when the institution in question is a nuclear agency. Nuclear agencies benefit from informational asymmetry.

They are able to shape preferences by manipulating information that those outside the agency cannot fully access or even understand. This particularly strong informational advantage stems from three special attributes that serve to limit outside knowledge of the nuclear program: Secrecy, the highly technical nature of nuclear science, and the awe and fear that surround the topic of nuclear weapons.

Future Avenues for Research

This dissertation advances our understanding of nuclear weapons program decision making. There are several possible areas for future research on this topic.

First, while I have identified start, acceleration, deceleration, and stop decisions for all states that have sought nuclear weapons, I confined this analysis to start and acceleration decisions only. Although I have conducted preliminary statistical analysis of deceleration and stop decisions, the relatively small number of these decisions meant that the models' results generally lacked statistical significance and robustness. A qualitative analysis of these decisions is one possible way to proceed in the future.

Second, I plan to rework the event history mode in Chapter 2 as a split-population event history model. The current model assumes that all states will eventually decide to start a nuclear weapons program. A split-population model would allow me to create a parameter differentiating between two populations of states: those that will eventually pursue a nuclear weapons program, and those that never will. These two groups of states face different odds of making a decision to start a nuclear weapons program.[3]

[3] See Box-Steffensmeier and Jones 2004, 148-154, and Milan Svolik, "Authoritarian Reversals and Democratic Consolidation," *The America Political Science Review*, Vol. 102, No. 2 (May 2008).

Since a split-population model requires the use of a parameter, I would no longer be able to use a Cox proportional hazards model and would need to impose restrictions on the shape of the baseline hazard. I would need to determine what assumption to make about time dependency in the data so that I could use an appropriate parametric model. From a purely practical standpoint, I did not attempt to estimate a split-population for the dissertation because there is no "canned" package for doing so, and the time needed to write the code is non-trivial.

Third, I am interested in the impact that nuclear agency independence may have on the likelihood of a decision to start. This project would require coding the institutional characteristics of the nuclear agencies of all states that have civilian nuclear programs. Using the same event history model I estimated in Chapter 2, I would include covariates measuring independence and origin of nuclear agency, and states would again drop out of the model upon deciding to start a nuclear weapons program.

Fourth, I will recode the covariate measuring the conventional threat posed by a state's rivals. The covariate I use does was not coded based on the definition of strategic rivalry, but used an older conceptualization of rivalry.

Finally, I plan to give further thought to the problem of operationalizing the notion of nuclear prestige. While it seems clear that the desire for prestige plays a role in state decision making regarding nuclear weapons, no one has been able to model that concept in any satisfying way. The prestige of belonging to the nuclear club has changed over time, but in different ways for different states. The pursuit of nuclear weapons has declined in legitimacy, yet states like Iran and North Korea continue to pursue them despite

international condemnation. Nuclear weapons remain a symbol of modernity and strength, and confer a special status upon the possessor state.

The desire for international prestige can have many different roots. For some leaders, it stems from a personal aspiration to global prominence. For others, prestige matters in the context of a rivalry. The drive for prestige can be heightened by a colonial history of oppression and condescension, or from the loss of territory. Thus, measuring a state's level of prestige-seeking is very difficult to do well. Perhaps an index composed of measurable components, such as a past or present struggle with occupation or colonization, or a moving count of militarized interstate dispute defeats, could be a first attempt at constructing such a variable.

Finally, the central implication of my findings is that domestic institutions and nuclear strategic rivalries affect the path and pace of nuclear weapons programs. An account of program decision making that relies solely on the conventional explanations of the personality traits of the executive and the state's security environment is incomplete and potentially misleading. To understand nuclear weapons program decision making, we must examine where executive preferences come from. The conditions under which domestic institutions are influential is a new and important part of the study of proliferation.

Appendix 1: Years of Decisions to Start Nuclear Weapons Program

In the following table, I compare the years used by Jo and Gartzke 2007, and the years I have identified, for each state's decision to start a nuclear weapons program. Differences are in bold; 11 of 24 states are different.

Year of Decision to Start Nuclear Weapons Program

	Jo and Gartzke 2007	Koch 2014
Germany	1941	1941
United Kingdom	1941	1941
Japan	1943	**1941**
United States	1942	1942
Russia	1943	1943
Australia	**.**	**1945**
Switzerland	**.**	**1946**
Yugoslavia	1953	**1947**
Sweden	1946	**1952**
France	1954	1954
China	1956	1956
Israel	1955	1955
India	1964	1964
Taiwan	1967	1967
North Korea	1982	**1968**
Libya	**.**	**1969**
Iraq	1973	**1971**
South Korea	1971	1971
Pakistan	1972	1972
South Africa	1975	**1974**
Iran	1974	1974
Brazil	1978	**1979**
Argentina	1976	1976
Syria	**.**	**1979**

Japan: Jo and Gartzke cite Wilcox (1985) for their 1943 start date, but Wilcox states on pages 56-59 that 1941 was the year the decision was made. This is confirmed by Shaplen

(1978). In April 1941, Lt. Gen. Yasuda Takeao, chief of Army Aviation Technology Research Institute, acted on PM Hideki Tojo's order to study and start a nuclear weapons program in Japan. By July 1941, the Riken research institute had received Army funding and began the program.

Australia: Reynolds (2000) uses 1945 as the year the Prime Minister decided to pursue nuclear weapons. Australia was linked in to British efforts at first and then shifted in 1964 to attempt to develop its own capability (Walsh 1997). Jo and Gartzke do not include Australia.

Switzerland: Swiss military historian Jürg Stüssi-Lauterberg (1996) wrote an account of the Swiss nuclear program that has not been clearly attributed. I confirmed with Stüssi-Lauterberg that he did write this account; Stüssi-Lauterberg has served for much of his career as head of the Swiss military archives. He writes that 1946 was the year of the political decision to issue secret orders regarding a militarized program. Jo and Gartzke do not include Switzerland in their data set.

Yugoslavia: Jo and Gartzke use 1953 as the decision date because an official document mentions nuclear weapons production as a goal. I use 1947, from James P. Nichol and Gordon L. McDaniel, "Yugoslavia," in Nuclear Power in Developing Countries, eds. James Everett Katz and Onkar S. Marwah (Lexington: D.C. Heath and Company, 1982), p. 346.

Sweden: Jonter (2001) writes that 1952 was the year of the "starting gun" that launched Sweden's militarized nuclear program. Jo and Gartzke relied instead on observations that Sweden began "marshalling resources" in the mid-1940s. The decision did not occur until later.

North Korea: There seems to be a fair amount of evidence that the North Korean program started in the late 1960s or early 1970s, not as late as 1982, which is the year Jo and Gartzke use. Both Spector (1990) and Mazarr (1995) write that North Korea had begun building nuclear weapons program infrastructure by the late 1970s; the political decision had to have occurred prior to that event. A South Korean source, who later worked for the IAEA, reported that North Korea asked China for nuclear weapons technology after its 1964 test, and that North Korea expanded its research institutions to support a nuc program for civilian and military applications in the late 1960s (Bermudez 1999). I use 1968 as a best, cautious estimate of an actual political decision.

Libya: After Qaddafi seizeed power, he quickly began seeking nuclear weapons (Bowen 2006). 1969 is most likely the year of the political decision. Jo and Gartzke do not include Libya in their data set. There is a good deal of evidence of a Libyan program, including the physical evidence of the more than $100 million of bomb-making technology, still some in their original packing crates, that Libya turned over to international nuclear inspetors in 2003 and 2004 (Bowen 2006, Sanger 2011).

Iraq: Generally, scholars agree that there was a buildup of activity in Iraq's nuclear program in the mid-1970s. The decision to start the militarized program (the increase in

activity followed) dates back to "the early 1970s," according to Braut-Hegghammer (2011); Reiter (2005) puts the decision at 1971.

Brazil: Declassified Brazilian government documents recently obtained by the Vargas Foundation reveal that the formal authorization of the parallel program was in 1979. See Chapter 5 for details.

South Africa: In 1974, the Atomic Energy Commission reports to Prime Minister Vorster that it can build a nuclear explosive device. The Prime Minister authorizes the development of nuclear explosives as well as locating a testing site (Reiss 1995, Albright 1994). Reiss and Albright both believe the correct year is 1974, both they each acknowledge this date is disputed by some who believe the decision came in 1978.

Syria: Information on Syria's nuclear weapons program is difficult to obtain. The Wisconsin Project uses 1979; the Nuclear Threat Initiative states that the military has been involved in Syria's nuclear program since the 1970s, and sought outside assistance in the 1980s. Jo and Gartzke do not include Syria in their data set.

Appendix 2: Decisions to Change the Pace of Nuclear Weapons Program

Argentina
Program starts in 1976. 1978: Acceleration. Argentina decides to build a spent-fuel reprocessing plant that could extract enough plutonium for 1-2 nuclear weapons per year, and also begins secret construction on gaseous diffusion uranium enrichment facility that could make highly enriched uranium. (Reiss 1995) 1983: Deceleration. Democratic elections held; military regime deposed. New president removes Navy head of CNEA, replaces him with civilian. Makes CNEA accountable to council of ministers within Foreign Ministry. Cuts CNEA's budget 40%. (Reiss 1995) 1990: Decision to end the weapons program. (Reiss 1995)

Australia
Program starts in 1945. 1964: Acceleration. Program shifts from trying to acquire nuclear weapons from the UK to trying to have an indigenous nuclear capability. (Walsh 1997) 1971: Deceleration. Labour comes into power, Jervis Bay reactor delayed, AAEC gutted, program starts to die off. (Moyal 1975) Program ended in 1972. (Walsh 1997)

Belarus
Inherits Soviet nuclear weapons on Belarus soil from independence in 1991. 1992: Decision to give everything, including strategic nuclear weapons, to Russia. (Reiss 1995)

Brazil
Program starts in 1979. 1982: Acceleration. New CNEN head "energizes" the militarized programs (Reiss 1995). 1983: Acceleration. Increased work on enrichment, a fast breeder reactor, and on a compact nuclear reactor for powering submarines. (Leventhal and Tanzer 1992) 1985: Deceleration. Nuclear agreement with Argentina, and around this time, budget cuts. (Reiss 1995) 1988: Deceleration. Work on Angra II reactor stalled. (Reiss 1995) President shuts down parallel program in 1990.

China
Program begins in 1955. 1960: Acceleration. Government decides to start crash program after USSR ceases its nuclear assistance to China. (Lewis and Xue 1988) 1964: Acceleration. Government sets goal of 1968 for first hydrogen bomb test. (Lewis and Xue 1988) 1977: Deceleration. CMC and State Council decide to focus on conventional weapons over strategic, overturning a nearly 20-year commitment to strategic weapons-based force modernization. 1978 is when Deng Xiaoping's demilitarization policy, which stems from this 1977 decision, begins to be put into place. (Feigenbaum 2003)

France
Program starts in 1954. 1958: Acceleration when Fifth Republic is created. Prime Minister issues order for preparations to be made to carry out nuclear tests. De Gaulle as PM orders development of military nuclear weapons program. (Norris et al 1994) 1972: Acceleration. Secret nuclear collaboration begins between France and US. Secret both because France wanted to appear independent, and U.S. Congress wouldn't have approved. (Norris et al 1994 With end of Cold War, deceleration. France scaled down materials production; some programs were cancelled, others were "stretched out or reduced," and government "revised downwards its production goals for nuclear materials." Major reorganization plan cancelling/retiring/limiting various nuclear forces made in early and mid 1989; implemented in Sept 1991. (Norris et al 1994, 200)

Germany
Program started in 1941 and ended with the 1945 defeat of Germany in World War II.

India
Program started in 1964. 1972: Acceleration. Decision to conduct explosion. After 1974 PNE ("peaceful nuclear explosion" – India's first nuclear test), the rest of the world stops their nuclear assistance to India. Government of India reacts to halting of assistance and by 1976 decides to slow progress – deceleration. 1981: Acceleration under Prime Minister Indira Gandhi (Spector 1990) 1984: Acceleration under Prime Minister Rajiv Gandhi – order to develop deliverable weapons. (Sidhu in Born 2010)

Iran
Program starts in 1974. 1975: Acceleration. Head of AEOI and Shah meet, and AEOI leaves meeting knowing he needs to start research and development on weapons as well as civilian uses of nuclear energy. He immediately instructs AEOI scientists to expand their research agendas. (Patrikarakos 2012) 1979: Deceleration. Ayatollah Khomeini essentially shuts down the nuclear program, and nuclear scientists flee. 1982: Acceleration as program is revitalized. (Patrikarakos 2012) 1985: Acceleration. Political decision to pursue indigenous uranium enrichment capability by way of a gas centrifuge program. AEOI began working on this, but lacked experience, so AEOI head Reza Amrollahi decided to look to the black market. He had the backing of Prime Minister Mousavi. (Patrikarakos 2012) 1997: Acceleration. In August, Khatami drastically changes AEOI and its nuclear program. Ayatollah Khamenei apparently is tired of slow progress and instructs Khatami to speed up. AEOI director Aghazadeh immediately gives the green light to begin work on heavy water reactors in Arak (the reactors were well-suited to produce plutonium). Also at this time was political decision to start up a uranium enrichment program. (Patrikarakos 2012) 2003: Deceleration – Khameni suspends work on weapons-related tech, although uranium enrichment continues. Later in year, Iran pledges to stop enrichment. (Patrikarakos 2012) 2006: Acceleration – Iran decides to restarts uranium enrichment at Natanz. (NYT 2013)

Iraq
Program starts in 1971. 1973: Acceleration. Braut-Hegghammer 2011 refers to it as a turning point, with instructions from Saddam Hussein to the nuclear establishment. Reiter says that Iranian revolution in 1979 accelerated Iraqi interest in getting a nuclear bomb,

and that in Dec 1979, Saddam Hussein told his nuclear scientists to forget about the Nuclear Non-proliferation Treaty and build a bomb. 1981: Acceleration. Israeli attack on Iraq's Osiraq reactor spurred Iraq's nuclear program forward (Reiter 2005) Saddam Hussein brought a nuclear physicist back from jail, moved entire program underground, etc. Brands & Palkki 2011 cite Solingen 2007 (Nuclear Logics, Princeton University Press) for this. 1990: Acceleration after invasion of Kuwait. Decision made to initiate crash program to develop bomb within 6 months. (Braut-Hegghammer 2011, Reiter 2005) Program ends in 1991 when Iraq loses the first Gulf War.

Israel
Program starts in 1955. According to Avner Cohen's books, which are the definitive sources on the Israel nuclear program, no acceleration or deceleration occurs through the 1960s, and Israel's policy of opacity makes it very hard to determine what's happened since early 1970s.

Japan
Program starts in 1941 and ends in 1945 when Japan is defeated in World War II.

Kazakhstan
1991: Kazakhstan inherits Soviet nuclear weapons when it gains independence. 1991 agrees to return tactical nuclear weapons to Russia. 1992 decision to give up nuclear weapons. (Reiss 1995)

Libya
Program starts in 1969. 1995 Acceleration: strategic decision to "reinvigorate" nuclear program. (IAEA Feb 2004 report) 2000: Acceleration when Libya begins ordering centrifuges for enriching uranium. (Bowen 2006) Program ends in 2003. (Bowen 2006)

North Korea
Program begins in 1968. 1981: Acceleration. Significant indigenous expansion. (NTI North Korea country profile 2011) 1994: Deceleration. DPRK slowed program. (Perkovich 1999, Reiss 1995) Program freezes for almost a decade and is rejuvenated in Dec 2002/Jan 2003. (NTI North Korea country profile 2011, Niksch 2010) 2007: Deceleration. International agreement. DPRK begins to shut down facilities at Yongbyon. 2008: Acceleration. DPRK restarts program, removing IAEA from facilities. (NTI 2011)

Pakistan
Program starts in 1972. 1974: Acceleration. Prime Minister accelerates the nuclear weapons program in June in order to advance as much as possible before international restrictions imposed post-Indian PNE take hold. (Khan 2013) 1977: General Zia-ul-Haq accelerates program by increasing development of uranium enrichment. (Kapur 1987, Khan 2013) 1989: Deceleration; arsenal seen as sufficient to establish credible deterrent. (Born et al 2010) 2001: Deceleration. PAEC classified budget cut 10%. Musharraf removes A. Q. Khan and PAEC chair from their positions. (Mushtaq 2001) 2009 acceleration (NYT 2009) in response to U.S. President Obama's Prague Speech.

Russia
Program starts in 1943. 1945: Acceleration. Stalin accelerated in response to the American uses of nuclear weapons. (Holloway 1994) 1951: Acceleration. Political decision to develop thermonuclear weapons. (Holloway 1994) 1953: Acceleration. Pace of testing increased, experimental ABM system called for when Khrushchev comes to power after Stalin's death. (Holloway 1994) 2001: Deceleration. Huge reductions to strategic nuclear forces. Funding cut dramatically. Modernization program slowed down. This drastic change was softened in 2002. (Born et al 2010)

South Africa
Program starts in 1974. 1975 Acceleration: Government urges scientists working on nuclear weapons at Pelindaba plant to double their efforts to complete first test detonation by end of 1975. (Masiza 1993) 1978 – South Africa doubles its army and triples its defense budget during late 1970s. Also decides to accelerate nuclear program – Prime Minister Vorster convenes senior officials to discuss this in 1977, then in April 1978 formally approves a draft document outlining nuclear course that the officials draw up. (Reiss 1995) 1985 Deceleration – In Sept, government decides to limit scope of weapons program, limiting the program to 7 weapons, stopping all work re: plutonium devices, and stopping all work to produce plutonim and tritium. Research and development work does continue on other aspects of the program. (Albright) 1989 – Political decision by President de Klerk to end program and dismantle and destroy the weapons.

South Korea
Program starts in 1971 and is canceled in 1978 (Spector 1990, Hayes 1988)

Sweden
Program starts in 1952. 1958: Deceleration when Defense Ministry directs FOA to shift research toward defensive uses of nuclear energy in 1958. (Arnett 1998) 1966: Deceleration when the Swedish government rejects the FOA's plan to establish a parallel military track, halts work on reprocessing plant and uranium facility, and cuts back FOA research dramatically. (Jonter 2010) 1968: governmental decision to end the "freedom of action" policy that has been the tacit acceptance of a military program is the final decision that ends the program. (Jonter 2010)

Switzerland
Program starts in 1946. 1955: Deceleration. (Stüssi-Lauterberg 1996) 1957: Acceleration. Program is reinvigorated when a new commission is created to promote the acquisition of nuclear weapons to the government. A year later, the government (Federal Council of Ministers) declares nuclear weapons are necessary for the Swiss army. (Stüssi-Lauterberg 1996) 1963: program accelerates. (Stüssi-Lauterberg 1996) 1969 Deceleration: Finance Department, Federal Financial Administration begin putting financial constraints on the program (for example, refusing to allow funding for uranium centrifuges). Funding for the program is hard to come by after this. In the same year, Switzerland signs the NPT, and although it doesn't ratify until 1977, it creates a new committee whose goal is to maintain a level of nuclear knowledge in Switzerland while, and after, the militarized program winds down. (Stüssi-Lauterberg 1996)

Syria
Program starts in 1979.

Taiwan
Program starts in 1967. 1977: Deceleration. U.S. pressures Taiwan to stop (they learned of program in early and mid 1970s). Taiwan dismantles its hot lab and most reprocessing facilities, dramatically decelerating the program. 1987: Acceleration. Taiwan secretly started building a small-scale plutonium extraction unit (Spector 1990, Campbell et all 2004). President Chiang Ching-kuo made the decision that accelerated (restarted) the program (Albright and Gay 1998). 1988: Program ends. Taiwan agrees to stop construction and to dismantle a 40-megawatt research reactor (at Institute for Nuclear Energy Research at Lung Tan) that Taiwan had gotten from Canada in 1969. (Spector 1990)

Ukraine
1991: Ukraine gained independence and inherited Soviet nuclear weaponry on its soil. Agrees to return all nuclear weapons, including strategic nuclear weapons, to Russia. 1992: Decides to nationalize nuclear weapons (although it can't, in reality, actually do that). 1993: Decides to return all nuclear weapons. (Reiss 1995)

United Kingdom
Program starts in 1941. 1947: Acceleration. Formal decision made to build an atomic bomb, and this decision leads to "an accelerated effort . . . holistic" to achieve this goal. (Norris et al 1994) (UK had tried to make this decision earlier, in Dec 1945, but the Cabinet committee tasked to make it couldn't agree on whether to proceed with building a bomb; Attlee had to create a new committee to make the Jan 1947 decision. Pontin 1989.) 1954: Acceleration. June decision to pursue hydrogen bomb. (Norris et al 1994) 1958: Deceleration. UK decides to rely on US for nuclear weapons. UK will pursue only a minimal indigenous arsenal (minimal compared to US and USSR). (Norris et al 1994) 1973: Acceleration. UK rejuvenates its program, starting work with the U.S. on Chevaline warhead. 1998: Deceleration. Strategy becomes "minimum nuclear deterrent." The UK dismantles air-delivered nuclear gravity bombs starting in 1991. (Simpson and Nielsen in Born 2010)

United States
Program starts in 1941. 1949L Acceleration. In response to Soviet nuclear test of Aug 26, President Truman approves an expansion of atomic bomb production capacity. He also decides to authorize the urgent development of the hydrogen bomb, and announces this decision on Jan 31, 1950. 1950: Acceleration. Truman decides to accelerate program by authorizing production of a weapon, not just a test, in a crash program. (Rhodes 1986) 1981 Reagan authorizes expansion of nuclear weapons program (Kimball 2004)

Yugoslavia
Program starts in 1947. 1961: Deceleration. Tito shifts to a civilian program. 1974: Acceleration. Tito restarts weapons program. Civilian program to be used as a cover for the parallel weapons program, "Program A." From Potter, Miljanic, Slaus, "Tito's Nuclear

Legacy," *Bulletin of the Atomic Scientists*, Vol 56 (2), March/April 2000. 1982: Acceleration. (Potter et al 2000) Then in 1986, Chernobyl accident led to a moratorium by Slovenian Parliament and then by Federal Council that ended all nuclear power-related research in Yugoslavia. Program ended 7 July 1987. (Potter et al)

Appendix 3: Cox Proportional Hazards Model for Start Decisions

Rather than a parametric model, I use a Cox model because I have no theoretical expectation regarding the shape of the hazard rate. While parametric models assume that hazard rates change over time in predetermined ways, the Cox model is semi-parametric, allowing the baseline hazard rate to fluctuate. Using a Cox model means that I am allowing the risk of starting a nuclear weapons program to rise or fall as time elapses.

Positive coefficients indicate that the hazard is increasing with changes in the covariate; negative coefficients indicate that the hazard is decreasing. In other words, positive coefficients mean the risk of starting a program is increasing, and negative coefficients mean the risk is decreasing.

The main table of results is below. As a robustness check, I tested several versions of this model. I used different codings of the dependent variable and of covariates when different scholars have used different versions:

- I alternately employed the Jo and Gartzke 2007 coding of defense pacts from ATOP data as well as the Bleek 2013 coding. Regardless of which coding I used, defense pacts were not significant. The rest of the model was not significantly affected by either coding.
- I alternately employed GDP per capita, GDP per capita squared, and an economic capacity measure constructed by Jo and Gartzke 2007. None of these measures was statistically significant, and none had a significant affect on the rest of the model.
- I used Jo and Gartzke's (2007) coding of political decision dates. Of the three covariates that were significant in all models using my coding of the dependent variable, one, nuclear strategic rivalry, just missed statistical significance at the $p<.10$ threshold when I used Jo and Gartzke's coding. I believe my coding is more accurate based on my careful and thorough comparison of sources, and my use of expert sources that Jo and Gartzke did not include. Jo and Gartzke also failed to include four states that pursued nuclear weapons.

The Cox model assumes that the proportions of the hazard funcitons are going to be the same as the values of the covariates change. If a covariate's effect changes over time, however, the proportional hazards assumption will be violated. If a covariate violates this assumption, the model will be misspecified and will overestimate or underestimate the impact of violating covariates, depending on whether those hazards are increasing or decreasing.

I test for proportional hazards violations using two different methods. I use Schoenfeld residuals, which are the observed minus the expected values of the covariates at each failure time. Plots of these residuals against time can show whether or not the covariate coefficient is time-dependent. I use a global and covariate-specific test to determine whether the hazard function is constant over time (Therneau and Grambsch 2000). I

regress the scaled Schoenfeld residuals on time. Globally and for all variables, results show that I cannot reject the null hypothesis of zero slope (no time dependency). There is no evidence from this test that the proportional hazards assumption has been violated. I repeated this test using a different functional form for time, log(t), and again, the null hypothesis could not be rejected. I then visually inspected Kaplan-Meier plots of Schoenfeld residuals against time for each covariate. All graphs showed relatively flat lines that did not display a relationship between residuals and time. Again, I could find no evidence from these plots that the proportional hazards assumption had been violated.

Finally, as a robustness check, I estimated the same versions of the event history model as a probit model instead. Using a probit model allows me to model the likelihood that a state will make a decision to start a program in each year. The probit results confirmed the validity of the results obtained from the event history models.

Appendix 4: List and Description of Covariates for Event History Model of Nuclear Weapons Program Start Decisions

Civil-Military Relations

This variable measures civilian control over the military. I use the index compiled by Jessica Weeks (Weeks 2012). Data is from 1946-1999. Used by permission of the author. I accessed Weeks's data set from her website:
http://falcon.arts.cornell.edu/jlw338/Jessica_Weeks/Research.html
I then used Weeks's "military dimension" to code this variable. The military dimension is constructed by answering five questions:

1. Is the leader a current or former high-ranking military officer?
2. Do officers hold cabinet positions not related to the armed forces?
3. Is military high command consulted primarily about security (as opposed to political) matters?
4. Are most members of the cabinet or politburo-equivalent civilians?
5. Does the Banks (2010) dataset[388] classify the government as either "military" or "military-civilian" (as opposed to "civilian")?

Civilian Nuclear Assistance

This variable, from Fuhrmann 2009, measures "the aggregate number of NCAs [nuclear cooperation agreements] that a state signed in a given year entitling it to nuclear technology, materials, or knowledge from another country." Used by permission of the author.

NPT Ratification

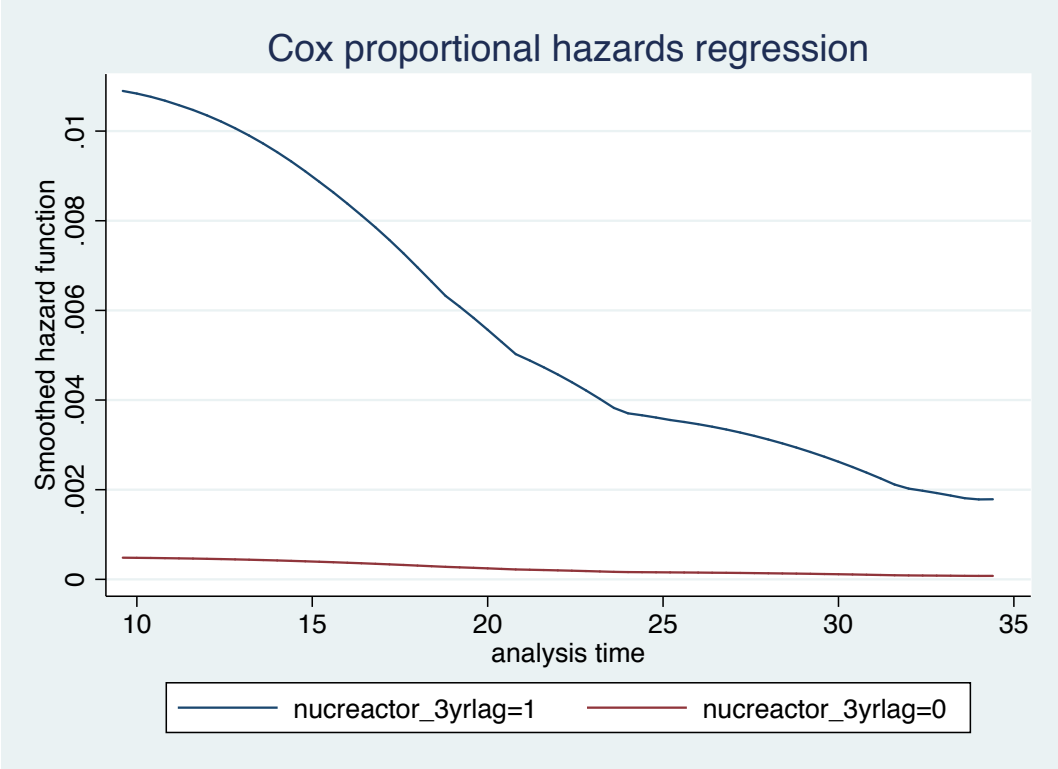
This variable is coded 1 if a state, other than the five declared nuclear powers, ratified the NPT, and 0 otherwise.

Nuclear Reactor Experience

This variable measures nuclear engineering capability, indicated by whether the country has had a nuclear reactor for more than 3 years. Data from Jo & Gartzke 2007 via the IAEA's PRIS database.

[388] Banks, Arthur S. 2010. Cross-National Time-Series Data Archive, Binghamton, NY. This is the standard dataset used by political scientists to assess civil-military relations worldwide.

Nuclear reactor graph of hazard rates indicating having a reactor puts you at greater risk of failure:



GDP per capita

This variable measures each country's GDP per capita for each year.

Regime Type

I use Polity IV scores to measure how democratic a regime is; scores become neutral (0) when a government is in a state of transition/anarchy. Data from Marshall, Monty G. and Keith Jaggers. 2002. *Polity IV Project: Political Regime Characteristics and Transitions, 1800-2002*. Version p4v2002e. College Park, MD: Center for International Development and Conflict Management, University of Maryland.

Disputes

In order to measure the security environment inhabited by a given state, I calculate the five-year moving average of the number of militarized interstate disputes (MIDs) per year in which a state is involved. (Singh and Way 2004; Fuhrmann 2009)

Defense Pact

I use two versions of this variable, one from Jo and Gartzke 2007 and one from Bleek 2013. Bleek's variable codes nuclear guarantees from the US and Russia once they had acquired nuclear weapons. Used by permission of the author.

If a state has a "nuclear guarantee" from a protector – in other words, a defense pact with a nuclear power – this variable is coded "1," and "0" otherwise.

Conventional Threat

This variable measures conventional threat to a state. From Jo & Gartzke 2007, calculated as follows:

$$\text{Conventional threat}_{i,t} = \ln\left(\sum_{j=1}^{n} \frac{CINC_{j,t}}{CINC_{i,t}} + 1\right)$$

This expression is the logged measure of the ratio of the conventional capabilities of a state's rival or rivals to that state's own conventional capabilities. CINC scores are index of 6 capability components for a given year as a share of the total components in the international system that year. CINC scores are from the Correlates of War project (Singer, Bremer, and Stuckey 1972).

The number 1 is added to the sum of the fractions because ln(1)=0. This scales the variable so that the smallest value obtainable, which occurs when a state has no rivals and thus the numerator is 0, will be ln(0 + 1) = 0.

Consider what this variable means, then. If a given state has:

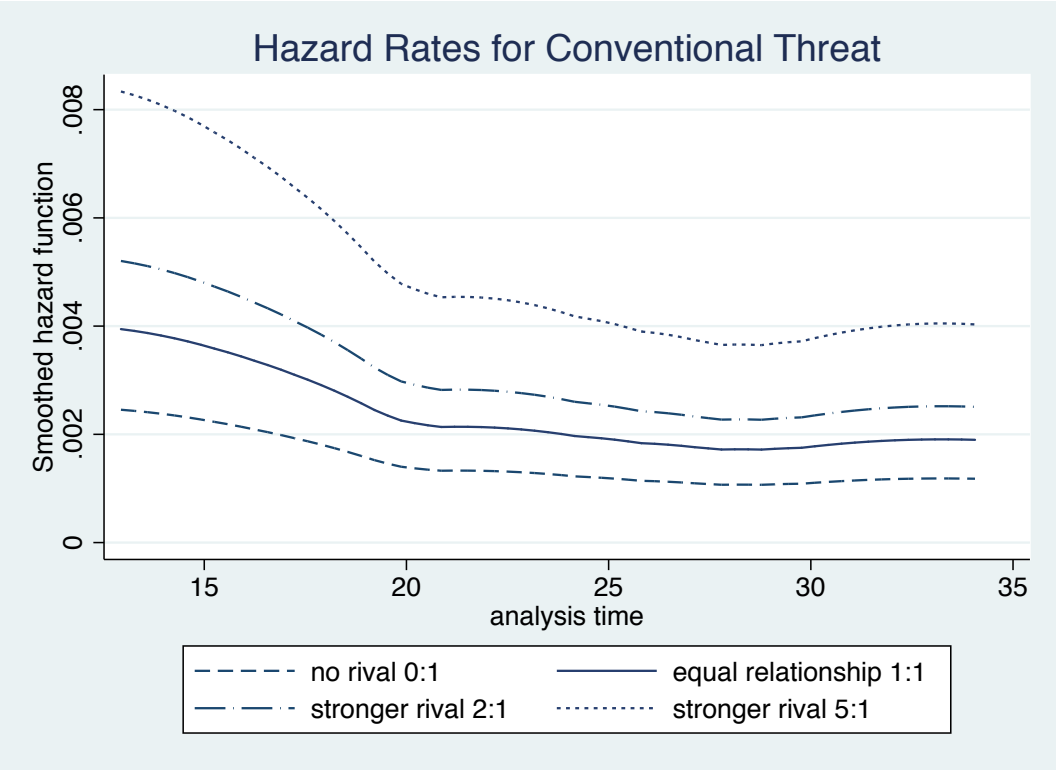
- No rivals: ln 1 = 0
- Rivals weaker than the state: ln (1<x<2) = some value greater than 0 and less than .693
- Rivals equal to the state: ln 2 = .6931
- Rivals stronger than the state: ln (x>2) = some value greater than .6931

Jo and Gartzke report the amount by which the probability of having a nuclear weapons program increases when the measure of conventional threat shifts from its mean to maximum value. However, comparing the mean value of this variable to the maximum value is misleading: it overestimates the impact of conventional threat.

The mean value of conventional threat in this data set is 0.14, while the maximum value is 3.24. Refer to the table above: a value of 0.14 indicates that the state has very weak rivals. The median value of conventional threat, in fact, is zero. Most states have no rivals; a minority of very high maximum values pull the mean up above zero. By comparing the mean value to the maximum value, Jo and Gartzke are reporting how the probability of a nuclear weapons program increases when conventional threat shifts from a near-zero threat to the greatest threat observed in the data set.

Instead, we should measure the difference in impact between values that are meaningful to the theory of conventional threat. To do that, I compare the hazard rate when a state has no rivals (0:1 ratio), to the hazard rate when the state has rivals of equal power (1:1 ratio), and then the hazard rate of an equal rivalry to various hazard rates when the state has stronger rivals. As reported in Chapter 2, I find that the substantive effect on risk is relatively small. The change in hazard rate from a state with no rivals to a state with

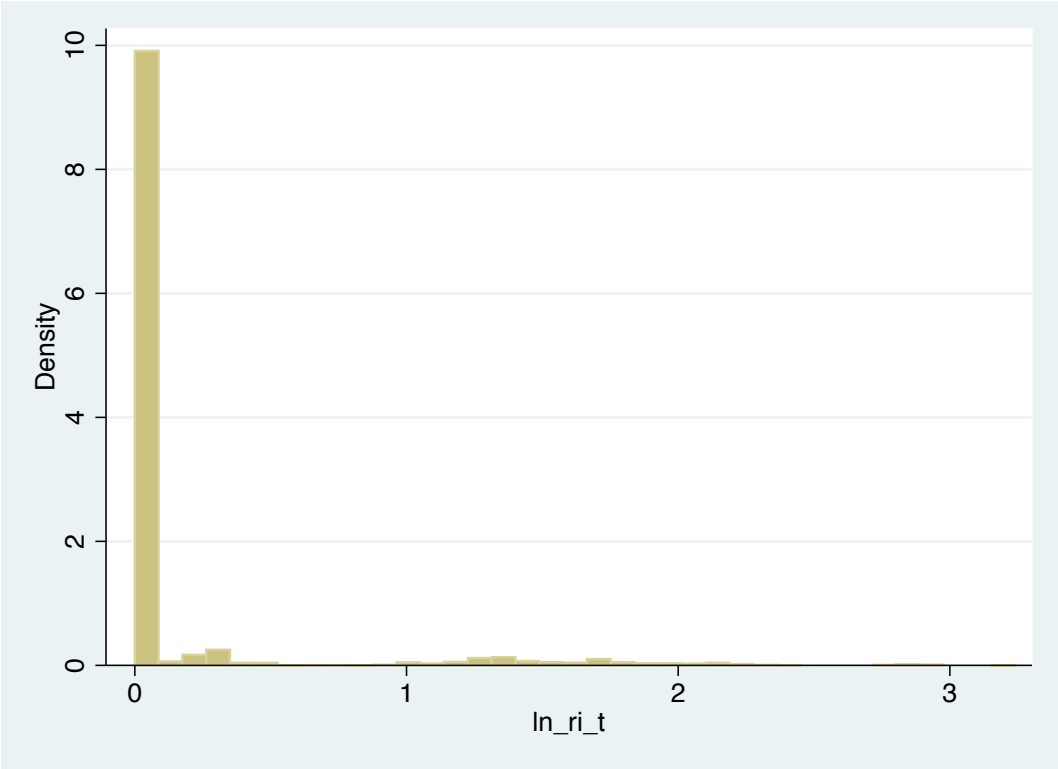
equal rivals is small, as is the change in hazard rate from a state with equal rivals to a state with rivals that are twice as powerful. In both of those cases, the hazard rate only increases by about .25. The hazard rate does not increase by a factor of two until the rivals possess five times the conventional capability of the state.



Only 2% of all observations fall at or above this 5:1 conventional capabilities ratio. Somalia, Afghanistan, and Taiwan comprise 68% of that 2%. The remaining states in this extremely threatened group are France (for three years), Germany (one year), Greece (one year), Angola (one year), Zimbabwe (one year), Libya (one year), Jordan (one year), *Israel* (eight years), China (three years), *Pakistan* (two years), Bangladesh (one year), Cambodia (twelve years), Laos (one year), and St. Vincent and the Grenadines (one year).

As I wrote in Chapter 2, Pakistan and Israel have been identified by scholars as the two cases in which conventional threat levels played a role in the decision to start a nuclear weapons program. Dropping either Israel or Pakistan from the data set (or both) causes conventional threat to lose its statistical significance at the $p<.10$ level. Other significant variables (nuclear strategic rivalry and nuclear reactor experience) are not adversely affected.

Histogram of conventional threat level values in data set. Most observations have a value of zero.



Nuclear Strategic Rivalry

I first coded strategic rivalries, from William R. Thompson and David Dreyer, Handbook of International Rivalries, 1494-2010 (Washington, DC: CQ Press, 2011). I then examined each rivalry to determine if either state was seeking or had acquired nuclear weapons at any point during the time of the rivalry The timespan of the *nuclear* strategic rivalry was based on my assessment of the year a rival's nuclear weapons program began. Each state that had a nuclear rival in a given year was coded with a 1, and 0 otherwise.

I estimated models both with and without strategic rivalry (the entire Thompson and Dreyer set of rivalries, regardless of whether any state was pursuing nuclear weapons) as a covariate. When I did not include the strategic rivalry variable, the effect of nuclear strategic rivalry was substantially higher than when I did. The risk of starting a program is ten times as high for a state with a nuclear strategic rival than for a state without this type of rival; if I include strategic rivalry in the model as well, the increase in risk drops from a factor of ten to a factor of five. This is still a strong effect, but certainly less strong. The effect of membership in a strategic rivalry, which is statistically significant at the $p<.10$ level, is to raise the risk by a factor of four. Since strategic rivalry and nuclear strategic rivalry overlap for some states, I also estimate the model with strategic rivalry as a covariate but without nuclear strategic rivalry; strategic rivalry is statistically significant and increases risk by almost 7 times, but it is still not quite as significant, and not as substantively strong, as nuclear strategic rivalry. Nuclear strategic rivalry is theoretically and mathematically the most compelling explanator.

Appendix 5: Results Table for Event History Model of Nuclear Weapons Program Start Decisions

Event history model of nuclear weapons program start decision making

Independent variable	Model 1 Coefficient estimate	Model 1 S.E.	Model 2 Coefficient estimate	Model 2 S.E.
Capacity				
GDP per capita	0.0001	0.0001	0.0001	0.0001
Nuclear reactor experience	1.4131*	0.7682	1.7313**	0.8133
Nuclear civilian assistance	–0.0112	0.0437	–0.0213	0.0464
Motivation				
Civil-military relations	–0.1293	0.9282	–0.4002	0.8599
Regime type	0.0119	0.0456	0.0001	0.0427
Militarized interstate disputes	0.0610	0.1552	0.0931	0.1505
Conventional threat level	0.8822**	0.3901	0.7292*	0.3846
Strategic rivalry	-	-	1.6612*	0.9315
Nuclear strategic rivalry	2.3984***	0.7296	1.9514***	0.6978
Defense pact	0.0287	0.6791	0.4745	0.6496
NPT ratification	–0.5131	0.8841	–0.1740	0.9193
Model N = 3258				

Note: *significant at p < .10; **significant at $p < .05$; ***significant at $p < .01$

Note: with other versions of model, in which I use different codings of certain covariates, the statistically significant variables remain statistically significant, and their coefficient estimates change within a very small margin. The coefficient estimate for nuclear reactor experience ranges from 1.73 to 1.8; conventional threat ranges from 0.68 to 0.73; strategic rivalry ranges from 1.66 to 1.73; nuclear strategic rivalry ranges from 1.9 to 1.95.

Appendix 6: Cox Proportional Hazards Model for Pace Decisions

Rather than a parametric model, I use a Cox model because I have no theoretical expectation regarding the shape of the hazard rate. While parametric models assume that hazard rates change over time in predetermined ways, the Cox model is semi-parametric, allowing the baseline hazard rate to fluctuate. Using a Cox model means that I am allowing the risk of starting a nuclear weapons program to rise or fall as time elapses.

Positive coefficients indicate that the hazard is increasing with changes in the covariate; negative coefficients indicate that the hazard is decreasing. In other words, positive coefficients mean the risk of starting a program is increasing, and negative coefficients mean the risk is decreasing.

See Appendix 3 for more about this type of model.

I test for proportional hazards violations using two different methods. I use Schoenfeld residuals, which are the observed minus the expected values of the covariates at each failure time. Plots of these residuals against time can show whether or not the covariate coefficient is time-dependent. I use a global and covariate-specific test to determine whether the hazard function is constant over time (Therneau and Grambsch 2000). I regress the scaled Schoenfeld residuals on time. Globally and for all variables, results show that I cannot reject the null hypothesis of zero slope (no time dependency). There is no evidence from this test that the proportional hazards assumption has been violated. I repeated this test using a different functional form for time, $\log(t)$, and again, the null hypothesis could not be rejected. I then visually inspected Kaplan-Meier plots of Schoenfeld residuals against time for each covariate. All graphs showed relatively flat lines that did not display a relationship between residuals and time. Again, I could find no evidence from these plots that the proportional hazards assumption had been violated.

The dependent variable measures decisions to accelerate nuclear weapons programs for states that have such programs. A decision to accelerate is coded as 1 for each year a decision is made. Years in which an acceleration decision is not made are coded with 0. After an acceleration decision is made, subsequent years are coded 0 once more until the next year of an acceleration decision.

Appendix 7: List and Description of Covariates for Event History Model of Program Acceleration Decisions

Civil-military relations

This variable measures civilian control over the military. I use the index compiled by Jessica Weeks (Weeks 2012). Data is from 1946-1999. Used by permission of the author. I accessed Weeks's data set from her website:
http://falcon.arts.cornell.edu/jlw338/Jessica_Weeks/Research.html
I then used Weeks's "military dimension" to code this variable. The military dimension is constructed by answering five questions:

1. Is the leader a current or former high-ranking military officer?
2. Do officers hold cabinet positions not related to the armed forces?
3. Is military high command consulted primarily about security (as opposed to political) matters?
4. Are most members of the cabinet or politburo-equivalent civilians?
5. Does the Banks (2010) dataset[1] classify the government as either "military" or "military-civilian" (as opposed to "civilian")?

Regime type

I use Polity IV scores to measure how democratic a regime is; scores become neutral (0) when a government is in a state of transition/anarchy. Data from Marshall, Monty G. and Keith Jaggers. 2002. *Polity IV Project: Political Regime Characteristics and Transitions, 1800-2002*. Version p4v2002e. College Park, MD: Center for International Development and Conflict Management, University of Maryland.

Agency origin

Agency independence

Disputes

In order to measure the security environment inhabited by a given state, I calculate the five-year moving average of the number of militarized interstate disputes (MIDs) per year in which a state is involved. (Singh and Way 2004; Fuhrmann 2009)

Strategic rivalry

For each year in which a state has a strategic rival, I code a 1, and 0 otherwise. I used William R. Thompson and David Dreyer, Handbook of International Rivalries, 1494-2010 (Washington, DC: CQ Press, 2011) to develop a list of strategic rivals. Used by permission of William R. Thompson.

[1] Banks, Arthur S. 2010. Cross-National Time-Series Data Archive, Binghamton, NY. This is the standard dataset used by political scientists to assess civil-military relations worldwide.

Nuclear strategic rivalry

I first coded strategic rivalries, from William R. Thompson and David Dreyer, Handbook of International Rivalries, 1494-2010 (Washington, DC: CQ Press, 2011). I then examined each rivalry to determine if either state was seeking or had acquired nuclear weapons at any point during the time of the rivalry The timespan of the *nuclear* strategic rivalry was based on my assessment of the year a rival's nuclear weapons program began. Each state that had a nuclear rival in a given year was coded with a 1, and 0 otherwise.

Conventional threat level

This variable measures conventional threat to a state. From Jo & Gartzke 2007, calculated as follows:

$$\text{Conventional threat}_{i,t} = \ln\left(\sum_{j=1}^{n} \frac{CINC_{j,t}}{CINC_{i,t}} + 1\right)$$

This expression is the logged measure of the ratio of the conventional capabilities of a state's rival or rivals to that state's own conventional capabilities. CINC scores are index of 6 capability components for a given year as a share of the total components in the international system that year. CINC scores are from the Correlates of War project (Singer, Bremer, and Stuckey 1972).

Defense pact

If a state has a "nuclear guarantee" from a protector – in other words, a defense pact with a nuclear power – this variable is coded "1," and "0" otherwise. I use Bleek's (2013) coding of nuclear guarantees from the US and Russia once they had acquired nuclear weapons. Used by permission of the author.

GDP

This variable measures each country's GDP per capita for each year.

Nuclear assistance

I code when a state is the recipient of nuclear civilian assistance via a signed agreement (referred to here as an NCA). Each time a state receives assistance in a given year, I count that NCA as "1." If a state receives assistance in year *y* from 6 different NCAs, I code that entry as "6."

Note that this variable differs from the "nuclear civilian assistance variable" I used in modeling start decisions. Whereas that variable measured the aggregate number of NCAs a state signed in a given year, my coding records the total number of NCAs active in a given year for the recipient state. The list of NCAs I use to develop this variable comes from Fuhrmann 2009. Used by permission of the author.

Appendix 8: Results Table for Event History Model of Nuclear Weapons Program Acceleration Decisions

Event history model of nuclear weapons program acceleration

Independent variable	Hazard ratio	S.E.	Coefficient estimate	S.E.
Civil-military relations	0.0465*	0.8430	–3.0682*	1.8128
Regime type	0.8480***	0.0517	–0.1649***	0.0610
Agency origin	2.7494**	1.2348	1.0114**	0.4491
Agency independence	2.0587***	0.4573	0.7221***	0.2221
Disputes	1.0244	0.1098	0.0241	0.1072
Strategic rivalry	4.3638	4.0205	1.4733	0.9213
Nuclear strategic rivalry	1.8220	1.4626	0.5999	0.8028
Conventional threat level	0.4617	0.2682	–0.7728	0.5810
Defense pact	1.0110	0.4044	0.0110	0.4000
GDP	1.0001**	0.0000	0.0001**	0.0000
Nuclear assistance	0.9920	0.0317	–0.0080	0.0319
Model N = 370				

Note: *significant at p < .10; **significant at p < .05; ***significant at p < .01

BIBLIOGRAPHY

Abraham, Itty. 1998. *The Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State*. New York: St Martin's Press.

Ahmed, Samina. 1999. "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices." *International Security*, Vol. 23, No. 4 (Spring): 178-204.

Albright, David. 1994. "South Africa and the Affordable Bomb." *Bulletin of the Atomic Scientists*, Vol 50(4), Jul/Aug.

Albright, David and Paul Brannan. 2011b. "Pakistan Doubling Rate of Making Nuclear Weapons." *Institute for Science and International Security*. May 16.

Albright, David and Corey Gay. 1998. "Taiwan: Nuclear Nightmare Averted." *Bulletin of the Atomic Scientists*. 54 (1) (Jan/Feb): 54-60.

Albright, David, Corey Gay, and Khidhir Hamza. 1999. "Development of the Al-Tuwaitha Site: What If the Public or the IAEA had Overhead Imagery?" ISIS Report, 26 April.

Albright, David and Mark Hibbs. 1993. "South Africa: The ANC and the atom bomb." *Bulletin of the Atomic Scientists* 49(3) April, 32–37.

Allen, Kenneth. 2002. "Introduction to the PLA's Administrative and Operational Structure," in Mulvenon, James C. and Yang, Andrew N. D., eds., *People's Liberation Army as Organization*, Santa Monica, Calif: RAND.

Allison, Graham. 1971. *The Essence of Decision: Explaining the Cuban Missile Crisis*. London: Longman.

Andersen, Per Kragh and Niels Keiding. 2002. "Multi-state Models for Event History Analysis." Statistical Methods in Medical Research. 11: 91-115.

Anderson, Robert S. 1975. "Building Scientific Institutions in India: Saha and Bhabha," Occasional Paper Series, No. 11, Centre for Developing-Area Studies at McGill University, Montreal.

Arnett, Eric. 1998. "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran." *The Nonproliferation Review*, 5:2, 32-43.

Arnold, Lorna and Mark Smith. 2006. *Britain, Australia and the Bomb*. New York: Palgrave Macmillan.

Bajpai, Kanti in Sagan, Scott D., ed. 2009. *Inside Nuclear South Asia*. Stanford: Stanford University Press.

Barletta, Michael. 1997. "The Military Nuclear Program in Brazil," Center for International Security and Arms Control (CISAC), Stanford University.

Beardsley, Kyle and Victor Asal. 2009. "Winning with the Bomb." *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 278-301.

Belkin, Aaron and Evan Schofer. 2003. "Toward a Structural Understanding of Coup Risk." *Journal of Conflict Resolution*, Vol. 47, No. 5 (Oct): 594-620.

Bennett, S. D. 1998. "Integrating and Testing Models of Rivalry Termination." *American Journal of Political Science*, 42: 1200-32.

Betts, Richard K. 1987. *Nuclear Blackmail and Nuclear Balance*. Washington, DC: Brookings Institution Press.

Braut-Hegghammer, Malfrid. 2011. "Revisiting Osirak: Preventive Attacks and Nuclear Proliferation Risks," *International Security*, 36:1, 101-132.

Bruneau, Thomas C. and Scott D. Tollefson, eds. 2006. *Who Guards the Guardians and How: Democratic Civil-Military Relations*. Austin: University of Texas Press.

Born, Hans, Bates Gill, and Heiner Hänggi, eds. 2010. *Governing the Bomb: Civilian Control and Democratic Accountability of Nuclear Weapons.* Oxford: Oxford University Press.

Bowen, Wyn Q. 2006. *Libya and Nuclear Proliferation: Stepping Back from the Brink*. Abingdon, Oxon: Routledge.

Box-Steffensmeier, Janet M. and Bradford S. Jones. 2004. Event History Modeling. New York: Cambridge University Press.

Buck, Alice. 1983. "The Atomic Energy Commission," U.S. Department of Energy, Office of History and Heritage Resources.

Bueno de Mesquita, Bruce, and William H. Riker. 1982. "An Assessment of the Merits of Selective Nuclear Proliferation." *Journal of Conflict Resolution* 26 (2): 283-306.

Byman, Daniel and Jennifer Lind. 2010. "Pyongyang's Survival Strategy: Tools of Authoritarian Control in North Korea." *International Security*, Vol. 35, No. 1: 44-74.

Campbell, Kurt M., Robert J. Einhorn, and Mitchell Reiss. 2004. *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*. Washington, DC: Brookings Institution Press.

Chakma, Bhumitra. 2008. *Pakistan's Nuclear Weapons*. New York: Routledge.

Cheibub, José Antonio, Jennifer Gandhi, and James Raymond Vreeland. 2010. "Democracy and Dictatorship Revisited." Public Choice, vol. 143, no. 2-1, pp. 67-101.

Chubin, S. 2006. *Iran's Nuclear Ambitions*. Washington, DC: Carnegie Endowment for International Peace.

Cirincione, Joseph. 2007*. Bomb Scare: The History and Future of Nuclear Weapons*. New York: Columbia University Press.

Cirincione, Joseph, Jon B. Wolfsthal, and Miriam Rajkumar. 2005. *Deadly Arsenals*. Washington, DC: Carnegie Endowment for International Peace.

Cohen, Avner. 1998. *Israel and the Bomb*. New York: Columbia University Press.

Cohen, Avner. 2010. *Worst-Kept Secret: Israel's Bargain with the Bomb*. New York: Columbia University Press.

Colaresi, Michael P., Karen Rasler and William R. Thompson. 2007. *Strategic Rivalries in World Politics*. Cambridge: Cambridge University Press.

Cole, Paul M. 1997. "Atomic Bombast: Nuclear Weapon Decision-Making in Sweden, 1946-72," *The Washington Quarterly*, 20:2, pp. 233-251.

Dahl, Per F. 1999. *Heavy Water and the Wartime Race for Nuclear Energy*. Bristol, UK: Institute of Physics Publishing.

Davis, Christopher M. 2004. "9/11 Commission Recommendations: Joint Committee on Atomic Energy – A Model for Congressional Oversight?" *CRS Report for Congress*, Washington, DC: Congressional Research Service (RL32538, 20 Aug).

Diehl, P. F. 1998. *The Dynamics of Enduring Rivalries*. Urbana: University of Illinois Press.

Elworthy, Scilla, "Nuclear Weapons Decision-making and Authority," in Marsh, Catherine and Colin Fraser, eds. 1989. *Public Opinion and Nuclear Weapons*. London: The Macmillan Press Ltd, pp. 165-176.

Erickson, Stanley A. 2001. "Economic and Technological Trends Affecting Nuclear Nonproliferation." *The Nonproliferation Review* (Summer): 40-54.

Fair, C. Christine. 2007. "India and Iran: New Delhi's Balancing Act." *The Washington Quarterly* Vol 30:3 (Summer): 145-159.

Feaver, Peter D. 1993. "Command and Control in Emerging Nuclear Nations." *International Security*,17:3 (Winter): 160-187.

Feaver, Peter D. 1992. *Guarding the Guardians*. Ithaca: Cornell University Press.

Feaver, Peter D. 1993. "Proliferation Optimism and Theories of Nuclear Operations." *Security Studies* Vol 2: 159-191.

Feaver, Peter D. and Christopher Gelpi. 2004. *Choosing Your Battles: American Civil-Military Relations and the Use of Force*. Princeton: Princeton University Press.

Feaver, Peter D., Scott D. Sagan, David J. Karl. 1997. "Proliferation Pessimism and Emerging Nuclear Powers." *International Security*, Vol. 22, No. 2 (Autumn): 185-207.

Feigenbaum, Evan A. 2003. *China's Techno-Warriors*. Stanford, California: Stanford University Press.

Flank, Steven. 1993. "Exploding the Black Box: The Historical Sociology of Nuclear Proliferation." *Security Studies*, Vol. 3, No. 1 (Winter): 259-94.

Foran, Virginia I., and Leonard S. Spector. 1997. "The Application of Incentives to Nuclear Proliferation." In *The Price of Peace: Incentives and International Conflict Prevention*, edited by David Cortright, 21-53. Boulder, CO: Rowman and Littlefield.

Fravel, M. Taylor and Evan S. Medeiros. 2010. "China's Search for Assured Retaliation." *International Security*, Vol. 35, No. 2(Fall): 48-87.

Fuhrmann, Matthew. 2009. "Spreading Temptation: Proliferation and Peaceful Nuclear Cooperation Agreements." *International Security*, 34:1 (Summer): 7-41.

Fuhrmann, Matthew. 2009. "Taking a Walk on the Supply Side: The Determinants of Civilian Nuclear Cooperation." *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 181-208.

Ganguly, Sumit and S. Paul Kapur. 2010. *India, Pakistan, and the Bomb*. New York: Columbia University Press.

Gelber, Harry G. 1972. "Australia and Nuclear Weapons," in Holst, Johan Jorgen, ed., *Security, Order and the Bomb: Nuclear Weapons in the Politics and Defence Planning of Non-Nuclear States*. Oslo: Universitetsforlaget.

Gilardi, Fabrizio. 2008. *Delegation in the Regulatory State*. Cheltenham: Edward Elgar Publishing Limited.

Gordin, Michael D. 2009. *Red Cloud at Dawn: Truman, Stalin, and the End of the Atomic Monopoly*. New York: Macmillan.

Halperin, Morton H. and Priscilla A. Clapp. 2006. *Bureaucratic Politics and Foreign Policy*. Washington, DC: Brookings Institution Press.

Hecht, Gabrielle. 1998. *The Radiance of France*. Cambridge, Mass: The MIT Press.

Hecker, Siegfried. 2010. "Lessons Learned from the North Korean Nuclear Crises." *Daedalus*, Vol. 139, No. 1: 44-56.

Herman, Michael. 1996. *Intelligence Power in Peace and War.* Cambridge: Royal Institute of International Affairs.

Hibbs, Mark. 2009. "US Knew in 1987 Pakistan Wanted Both Nuclear Weapons and Aid." *Nuclear Fuel*, 28 December.

Holloway, David. 1994. *Stalin and the Bomb*. New Haven: Yale University Press.

Horowitz, Michael. 2009. "The Spread of Nuclear Weapons and International Conflict: Does Experience Matter?" *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 234-257.

Howell, William G. and David E. Lewis. 2002. "Agencies by Presidential Design." *Journal of Politics*, 64(4): 1095-1114.

Huntington, Samuel P. 1957. *The Soldier and the State*. Cambridge: Harvard University Press.

Huth, Paul and Bruce Russett. 1993. "General Deterrence between Enduring Rivals: Testing Three Competing Models." *American Political Sceince Review*, 87:61-73.

"*India Helping Iran With Nuclear Energy Programme: Foreign Minister*," Agence France-Presse, December 13, 2003.

Jennergren, C. G., Stephan Schwarz, and Olov Alvfeldt. 1977. *Trends in Planning: A Collection of Essays from the Planning Department of the Swedish National Defense Research Institute (FOA)*. Stockholm: Forsvarets Forskningsanst.

Jo, Dong-Joon and Erik Gartzke. 2007. "Determinants of Nuclear Proliferation." *Journal of Conflict Resolution*, Vol. 51, No. 1 (Feb): 167-194.

Jo, Dong-Joon and Erik Gartzke. 2009. "Bargaining, Nuclear Proliferation, and Interstate Disputes." *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 209-233.

John, Wilson. 2005. *Pakistan's Nuclear Underworld: An Investigation*. New Delhi: Samskriti.

Johnston, Alastair Iain. 1996. "China's New 'Old Thinking': The Concept of Limited Deterrence." *International Security*, Vol. 20, No. 3 (Winter): 5-42.

Jonter, Thomas. 2001. "Sweden and the Bomb," SKI (Swedish Nuclear Power Inspectorate) Report 01:33, ref. 14.10-991390/00084.

Jonter, Thomas. 2010. "The Swedish Plans to Acquire Nuclear Weapons, 1945-1968: An Analysis of the Technical Preparations," Science & Global Security, 18:61-86.

Khan, Feroz Hassan. 2013. *Eating Grass: The Making of the Pakistani Bomb*. New Delhi: Cambridge University Press.

Kahn, Saira. 2010. *Iran and Nuclear Weapons: Protracted Conflict and Proliferation*. New York: Routledge.

Kong, Yan. 1993. "China's Nuclear Bureaucracy." Jane's Intelligence Review, (July): 320-326.

Kaplan, Fred. 1983. *The Wizards of Armageddon*. New York: Simon and Schuster.

Kapur, Ashok. 1987. *Pakistan's Nuclear Development*. London: Croom Helm.

Kapur, Ashok. 2001. *Pokhran and Beyond: India's Nuclear Behavior*. New Delhi: Oxford University Press.

Kapur, S. Paul. 2003. "Nuclear Proliferation, the Kargil Conflict, and South Asian Security." *Security Studies* 13:1, pp. 79-105.

Kassenova, Togzhan. 2014. *Brazil's Nuclear Kaleidoscope: An Evolving Identity*. Washington, DC: Carnegie Endowment for International Peace.

Kerr, Paul K. and Mary Beth Nikitin. 2012. "Pakistan's Nuclear Weapons: Proliferation and Security Issues." *CRS Report for Congress*, Washington, DC: Congressional Research Service (RL34248, 26 June).

Khariton, Yuli and Yuri Smirnov. 1993. "The Khariton Version," *Bulletin of the Atomic Scientists*, May, 20-31.

Kimball, Daryl G. 2004. "Looking Back: The Nuclear Arms Control Legacy of Ronald Reagan." *Arms Control Today*, July/August.

Kincade, Walter. 1991. "The United States: Nuclear Decision-making 1939-89," in Regina Cowen Karp, ed., *Security with Nuclear Weapons?*, Oxford: Oxford University Press, pp. 21-56.

Koithara, Verghese. 2012. *Managing India's Nuclear Forces*. Washington, DC: Brookings Institution Press.

Krause, George A. 1996. "The Institutional Dynamics of Policy Administration: Bureaucratic Influence over Securities Regulation." *American Journal of Political Science*, 40:1083-1121.

Kristensen, Hans and Norris, Robert. 2011. "Pakistan's Nuclear Forces, 2011." *Bulletin of the Atomic Scientists*. July/Aug vol 67 no 4 pg 91-99.

Kroenig, Matthew. 2009. "Importing the Bomb: Sensitive Nuclear Assistance and Nuclear Proliferation." *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 161-180.

Leventhal, Paul L. and Sharon Tanzer, eds. 1992. *Averting a Latin American Nuclear Arms Race: New Prospects and Challenges for Argentine-Brazil Nuclear Co-operation*. New York: St. Martin's Press.

Levy, Jack S. and Lily I. Vakili. 1992. "Diversionary Action by Authoritarian Regimes: Argentina in the Falklands/Malvinas Case," in *Handbook of War Studies*, ed. M. I. Midlarsky. Ann Arbor: University of Michigan Press.

Lewis, John Wilson and Xue Litai. 1988. *China Builds the Bomb*. Stanford: Stanford University Press.

Liberman, Peter. 2001. "The Rise and Fall of the South African Bomb." *International Security*, Vol. 26, No. 2, Fall, p. 45-86.

Lindsay, James M. 1991. *Congress and Nuclear Weapons*. Baltimore: The Johns Hopkins University Press.

Littke, Ann Katherine and Sundström, Olle, eds. 1995. *Försvarets forskningsanstalt 1945-1995*. Stockholm: Probus Förl. [Swedish language]

Maggetti, Martino. 2007. "De Facto Independence After Delegation: A Fuzzy-set Analysis." *Regulation & Governance*, 1: 271-294.

Malik, Zahid. 1992. *Dr. A. Q. Khan and the Islamic Bomb*. Islamabad: Hurmat.

Mandelbaum, Michael. 1995." Lessons of the Next Nuclear War." *Foreign Affairs* 74 (2): 22-37.

Mazarr, Michael J. 1995. *North Korea and the Bomb*. New York: St. Martin's Press.

McDonnell, Timothy. 2013. "Nuclear Pursuits: Non-P-5 Nuclear-Armed States, 2013," *The Bulletin of the Atomic Scientists* 69:62.

McLean, Scilla, ed. 1986. *How Nuclear Weapons Decisions are Made*. New York: St. Martin's Press.

Medalia, Jonathan, *et al*. 2011. "Nuclear Weapons R&D Organizations in Nine Nations." *CRS Report for Congress*, Congressional Research Service (R40439, 28 February).

Meyer, Stephen M. 1984. *The Dynamics of Nuclear Proliferation*. Chicago: The University of Chicago Press.

Miall, Hugh. 1987. *Nuclear Weapons: Who's in Charge?* London: The MacMillan Press Ltd.

Miller, Gary J. 2005. "The Political Evolution of Principal-Agent Models," *Annual Review of Political Science*, 8:203-225.

Miscamble, Wilson D. 1993. *George F. Kennan and the Making of American Foreign Policy, 1947-1950*. Princeton: Princeton University Press.

Montgomery, Alexander H. and Scott D. Sagan. 2009. "The Perils of Predicting Proliferation." *Journal of Conflict Resolution*, Vol. 53, No. 2 (Apr): 302-328.

Moyal, Ann Mozley. 1975. "The Australian Atomic Energy Commission: A Case Study in Australian Science and Government." *Search*, Vol. 6, No. 9 (Sept): 365-384.

Mushtaq, Najum. 2001. "Pakistan: Khan Forced Out." *Bulletin of the Atomic Scientists*, 57:13.

Narang, Vipin. 2009. "Posturing for Peace?: The Deterrence Consequences of Regional Power Nuclear Postures." Paper presented at APSA Annual Conference, Toronto, 3 Sept 2009.

Narang, Vipin. 2010. "Posturing for Peace? Pakistan's Nuclear Postures and South Asian Stability." *International Security*, Vol. 34, No. 3 (Winter): 38-78.

Narang, Vipin. 2014. *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict*. Princeton: Princeton University Press.

Neufeld, Jacob. 1990*. The Development of Ballistic Missiles in the United States Air Force 1945-1960*, Washington, D.C.: Office of Air Force History, United States Air Force.

Niksch, Larry A. 2010. "North Korea's Nuclear Weapons Development and Diplomacy." *Congressional Research Service*.

Norris, Robert S., Andrew S. Burrows, and Richard W. Fieldhouse. 1994. *Nuclear Weapons Databook*, *Volume 5, British, French, and Chinese Nuclear Weapons*. Boulder, Colo.: Westview Press.

Patrikarakos, David. 2012. *Nuclear Iran: The Birth of an Atomic State*. London: I.B. Tauris & Co Ltd.

Patti, Carlo. 2011. "Origins and Evolution of the Brazilian Nuclear Program (1947-2011)," for the Nuclear Proliferation International History Project of the Wilson Center at www.wilsoncenter.org.

Paul, T.V. 2009. *The Tradition of Non-Use of Nuclear Weapons*. Stanford: Stanford University Press.

Perkovich, George. 1999. *India's Nuclear Bomb: The Impact on Global Proliferation*. Berkeley: University of California Press.

Pollack, Joshua. 2010. "Tracing Syria's Nuclear Ambitions." *The Journal of International Security Affairs*. No. 19 Fall/Winter.

Pontin, Clive, "Defense Decision-making and Public Opinion: A View from the Inside," in Marsh, Catherine and Colin Fraser, eds. 1989. *Public Opinion and Nuclear Weapons*. London: The Macmillan Press Ltd, pp. 177-191.

Posen, Barry R. 1984. *The Sources of Military Doctrine*. Ithaca: Cornell University Press.

Potter, W. C. 1982. *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective*. Cambridge: Oelgeschlager Gunn and Hain.

Potter, William C., ed. 1990. *International Nuclear Trade and Nonproliferation*. Lexington, Mass.: Lexington Books.

Potter William C., Djuro Miljanic, and Ivo Slaus. 2000. "Tito's Nuclear Legacy," *Bulletin of the Atomic Scientists*, 56:2, 63-70.

Press, Daryll G., Scott D. Sagan, and Benjamin A. Valentino. 2013. "Atomic Aversion: Experimental Evidence on Taboos, Traditions, and the Non-Use of Nuclear Weapons," *American Political Science Review*, 107:1, 188-206.

Quester, George. 1973. *The Politics of Nuclear Proliferation*. Baltimore: Johns Hopkins University Press.

Quester, George. 2005. *Nuclear First Strike: Consequences of a Broken Taboo*. Baltimore: Johns Hopkins University Press.

Reed, Thomas C. and Danny B. Stillman. 2010. *The Nuclear Express*. Minneapolis: Zenith Press.

Reiss, Mitchell. 1995. *Bridled Ambition: Why Countries Constrain Their Nuclear Capabilities*. Washington, D.C.: Woodrow Wilson Center Press.

Reiss, Mitchell. 1988. *Without the Bomb: The Politics of Nuclear Nonproliferation*. New York: Columbia University Press.

Reiter, Dan. 2005. "Preventive Attacks Against Nuclear Programs and the 'Success' at Osiraq," *The Nonproliferation Review*, 12:2, 335-371.

Reynolds, Wayne. 2000. *Australia's Bid for the Atomic Bomb*. Melbourne: Melbourne University Press.

Rhodes, Richard. 1986. *The Making of the Atomic Bomb*. New York: Simon & Schuster.

Rosenberg, David A. "The History of World War III 1945-1990: A Conceptual Framework," in Robert David Johnson, ed., On Cultural Ground: Essays in International History (Chicago: Imprint Publications, 1994), 197-235.

Rublee, Maria Rost. 2009. *Nonproliferation Norms: Why States Choose Nuclear Restraint*. Athens, GA: University of Georgia Press.

Sagan, Scott D. 1996/1997. "Why Do States Build Nuclear Weapons: Three models in Search of a Bomb." *International Security*, 21, 3 (Winter): 54-86.

Sagan, Scott D., ed. 1994. *Civil-Military Relations and Nuclear Weapons*. Stanford: Center for International Security and Arms Control.

Sagan, Scott D. 2009. "The Evolution of Pakistani and Indian Nuclear Doctrine," in *Inside Nuclear South Asia*. Stanford: Stanford University Press.

Sagan, Scott D. and Kenneth N. Waltz. 2003. *The Spread of Nuclear Weapons: A Debate Renewed*. New York: W. W. Norton & Company.

Sanger, David E. 2011. "In U.S.-Libya Nuclear Deal, a Qaddafi Threat Faded Away." *The New York Times*, 1 March.

Sasikumar, Karthika and Christopher Way. 2009. "Testing Theories of Proliferation in South Asia." In Scott D. Sagan, ed., *Inside Nuclear South Asia*. Palo Alto: Stanford University Press.

Schwartz, Stephen I., ed. 1998. *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940*. Washington, DC: Brookings Institution Press.

Schwartz, Stephen I. 2008. "The Costs of U.S. Nuclear Weapons." James Martin Center for Nonproliferation Studies, Monterey Institute for International Studies, October. [Accessed via The Nuclear Threat Initiative at www.nti.org]

Sechser, Todd S. 2004. “Are Soldiers Less War-Prone than Statesmen?” *The Journal of Conflict Resolution*, Vol. 48, No. 5 (Oct): 746-774.

Seongwhun, Cheon. 2005. *Toward Greater Transparency in Non-Nuclear Policy: A Case of South Korea*. Seoul: The Korea Institute for National Unification.

Sethi, Manpreet. 1999. *Argentina’s Nuclear Policy*. New Delhi: Knowledge World in assn. with Institute for Defence Studies and Analyses.

Shapley, Deborah. 1978. “Nuclear Weapons History: Japan’s Wartime Bomb Projects Revealed,” *Science*, 199: 152-7.

Singer, David E. and William J. Broad. 2011. “U.N. Finds Signs of Work by Iran Toward Nuclear Device,” *The New York Times*, 8 November.

Singer, J. David, Stuart Bremer, and John Stuckey. 1972. "Capability Distribution, Uncertainty, and Major Power War, 1820-1965," in Bruce Russett (ed) *Peace, War, and Numbers*, Beverly Hills: Sage, 19-48.

Singh, Sonali and Christopher R. Way. 2004. “The Correlates of Nuclear Proliferation: A Quantitative Test.” *Journal of Conflict Resolution*, Vol. 48, No. 6 (Dec): 859-885.

Slocombe, Walter. 2006. “Democratic Civilian Control of Nuclear Weapons.” Policy Paper No. 12, Geneva: Centre for the Democratic Control of Armed Forces Geneva.

Snyder, Jack. 1984. *The Ideology of the Offensive*. Ithaca: Cornell University Press.

Spector, Leonard S. 1990. *Nuclear Ambitions: The Spread of Nuclear Weapons 1989-1990*. Boulder: Westview Press.

Spector, Leonard S. 1984. *Nuclear Proliferation Today*. New York: Random House.

Spector, Leonard S. 1988. *The Undeclared Bomb*. Cambridge, Mass: Ballinger.

Stüssi-Lauterberg, Jürg. 1996. “Historical Outline on the Question of Swiss Nuclear Armament.” Federal Administration, Bern. Report: April. Excerpts translated into English from German.

Therneau, Terry M. and Patricia M. Grambsch. 2000. Modeling Survival Data: Extending the Cox Model. New York: Springer.

Verhoest, Koen, B. Guy Peters, Geert Bouckaert, and Bran Verschuere. 2004. “The Study of Organisational Autonomy: A Conceptual Review,” *Public Administration and Development*, 24: 101-118.

Von Hippel, Frank. 2004. *Russian Strategic Nuclear Forces*. Cambridge, Mass: MIT Press.

Walsh, Jim. 1997. "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions." *The Nonproliferation Review*, Fall.

Weber, Max. 1946. *Max Weber: Essays on Sociology*. New York: Oxford University Press.

Weeks, Jessica L. 2008. "Autocratic Audience Costs: Regime Type and Signaling Resolve." *International Organization* 62 (Winter): 35-64.

Weeks, Jessica L. 2012. "Strongmen and Straw Men: Authoritarian Regimes and the Initiation of International Conflict," American Political Science Review, 106:2, 327-346.

Weissman, Steve and Herbert Krosney. 1981. *The Islamic Bomb*. New York: Times Books.

Wilcox, Robert K. 1985. *Japan's Secret War*. New York: William Morrow and Company, Inc.

Wisconsin Project. 2009. "Syria Nuclear Milestones 1963-2009." *The Risk Report*, Vol 15, No. 3, May-June, at www.wisconsinproject.org.

Wood, B. Dan, and John Bohte. 2004. Political Transaction Costs and the Politics of Administrative Design. *Journal of Politics* (Feb): 176-202.

York, Herbert. 1971. "*Race to Oblivion: A Participant's View of the Arms Race*." New York: Simon and Schuster.

Ziegler, Charles A. 1995. *Spying without Spies: Origins of America's Secret Nuclear Surveillance System*. Westport: Praeger Publishers.

_____. 2006. *Kazakhstan's Nuclear Disarmament: a Global Model for a Safer World*. Washington, DC: Embassy of Kazakhstan.