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# Nukes with Numbers: Empirical Research on the Consequences of Nuclear Weapons for International Conflict

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international security, conflict, war, militarized disputes, proliferation, deterrence, compellence

## Abstract

Research on nuclear security has gone quantitative. Rapid growth in empirical approaches to the consequences of nuclear weapons in recent years promises to settle some controversies, even as it initiates or resurrects debates that may eventually be resolved with better estimates or data. The toolkit for studying nuclear security had long been bereft of quantitative approaches, undermining the virtuous cycle between theory and evidence. New data and growing confidence in statistical approaches have finally produced a systematic empirical literature on the consequences of nuclear weapons. We review existing studies, organizing the literature along thematic lines. We also discuss challenges facing the emergent quantitative literature and suggest several avenues for future research. Although the terminus of the basic research agenda has been anticipated more than once, the literature on nuclear consequences has shown a remarkable ability to generate novel and often unexpected research questions.

## INTRODUCTION

The advent of nuclear weapons is widely believed to have dramatically altered the nature and conduct of international affairs. Indeed, there may be no other subject in international relations where careful assessment of evidence is likely to prove more crucial to the survival of humanity. At the same time, however, nuclear security as a subject offers almost no direct empirical referent. Relatively few countries possess nuclear weapons—the spread of nuclear capabilities has fortunately progressed much more slowly than many originally feared—and the use of nuclear weapons in anger has not recurred in the seven decades that have passed since the twin bombings of Hiroshima and Nagasaki at the end of World War II.

In the absence of direct evidence about how nuclear weapons impact war and peace, pundits, scholars, and politicians have been forced to deduce these and other consequences of nuclear weapons using logic, or to infer from sparse anecdote or analogy. Theories of nuclear security have been increasingly carefully crafted, but in the absence of critical empirical tests, these ideas risk becoming accepted or rejected on the basis of individual or social biases or authority rather than challenged, criticized, and validated as scientific laws. Claims about the consequences of nuclear weapons have become established in various communities or institutional settings substantially through selective examples or preconception. Concepts as fundamental as nuclear deterrence, though persuasive, remain subject to empirical scrutiny, and controversies about the nature of nuclear stability remain rooted in arguments that, while important and engaging, have not had sufficient opportunity to evolve beyond well-established debating points (Sagan & Waltz 2012).

Despite the near absence of overt nuclear conflict, scholars and policy makers require answers to a great many related issues. Do nuclear weapons deter conflict? If so, how much nuclear capability is enough for deterrence? Does nuclear superiority carry with it additional benefits? Do nuclear strategy, delivery vehicles, and other details of nuclear force posture contribute to deterrence? Can countries extend nuclear deterrence to allies? Do nuclear posture and strategy influence nuclear weapons proliferation decisions in other countries? Does deployment of nuclear weapons on the territory of an ally enhance deterrence or dissuade allied nuclear proliferation? How credible is a so-called nuclear umbrella in different deterrence contexts, with different allies? Do nuclear weapons provide benefits other than deterrence, such as in the exercise of coercive foreign policy? Are nuclear states more effective in bargaining in international affairs? Do nuclear weapons have symbolic value that can, for example, increase international prestige?

Recent research has begun to augment theory and case studies with statistical analysis of the impact of nuclear capabilities on these and other questions. Despite apparent obstacles, the last decade has witnessed a veritable explosion of empirical research on the consequences of nuclear weapons for war, peace, and international politics more generally.

There are at least two reasons for the recent renaissance in nuclear security studies. The first comes from changes in world affairs and a perceived increase in the salience of nuclear and other weapons of mass destruction for foreign policy. The vigorous efforts of revisionist states to acquire nuclear weapons suggest a preconception about the utility of these devices, beliefs that may or may not be justified but certainly merit careful empirical assessment. After a long period during which the total number of nuclear weapons in the world steadily declined, the established nuclear powers are once again procuring new systems, with new philosophies for the deployment and use of these weapons. Issues that receded into the background for a generation or more are again coming to the fore as more mature nuclear nations re-engineer aging stockpiles or modernize and diversify their strategic deterrent. It is often assumed that because we all survived the Cold War the old nuclear security dynamics must have been well understood, but this could have been the result of luck as much as wisdom. The role of middle nuclear powers—never subject to adequate

analytical attention—has become much more salient in a multipolar world. Newer nuclear nations also appear destined to further complicate the old bilateral nuclear framework, forcing deterrence theory to consider multiple actors and many objectives at once. In short, after a long period of dormancy, students and practitioners of international relations are reawakening to the dangers of a nuclearized world, and to new opportunities for careful empirical study of a subject that merits extensive analytical attention.

The second reason for the renewed interest in this subject is more practical. As time has passed since the invention of nuclear weapons in 1945, more data have become available on how nuclear weapons affect state behavior. In addition, disciplinary standards that emphasize multimethod analysis have motivated a new generation of scholars to begin to systematically collect data and to acquire or deploy the research skills necessary to analyze them.

This new research has already begun to question or reaffirm basic beliefs about the nature and consequences of nuclear weapons, beliefs that are often entrenched as what might be called the folklore of security doctrine and practice. In some cases, this has involved reigniting old controversies. In other instances, it has led to new doubts about long-accepted “facts.” Although none of the debates are settled, the weight of emerging scholarship seems to suggest that nuclear weapons do deter and may influence other states more generally, that the details of nuclear posture and strategy matter more than previous scholarship acknowledged, and that nuclear weapons also affect aspects of international politics beyond mere conflict dynamics.

This new research may still have a way to go to convince a plurality of scholars, policy practitioners, and the public of the validity of a growing list of findings, but it surely makes sense to use proven social science tools to assess the implications of nuclear weapons for stability and conflict. This new research provides a number of insights and opportunities for future investigation that we discuss below. It also poses challenges that must be overcome, or at least addressed, as this literature evolves. Perhaps most important, new research on nuclear security offers the potential to generate a wave of additional theoretical refinements.

## THE THEORY CONUNDRUM

In the aftermath of World War II, theory took on a dominant role in addressing a new and menacing technology. Nuclear weapons were unprecedented; winning, or even surviving, in this new era seemed to require a different rule book, one that was not yet available. It was feared that humanity might not survive long enough to develop the practical experience with nuclear weapons that had been acquired and applied to politics with conventional military capabilities. Scholars like Brodie (1946, 1959), Kahn (1960), and Kissinger (1957) looked to deterrence theory for intellectual guidance and the sources of strategic stability.<sup>1</sup> The father of game theory, John von Neumann, coined the term mutual assured destruction (MAD) to characterize the first US nuclear doctrine of massive retaliation. Schelling (1960) in particular captured the strategic logic of MAD, emphasizing the need for an irrational final action at the core of rational (nuclear) deterrence theory, something that remains subject to controversy to this day (Powell 1990). The Cold War ended and deterrence was declared a success without definitive evidence about how the United States and other nuclear powers actually managed to avoid World War III. Several questions remain about how deterrence actually works in practice and how it will function in the future.

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<sup>1</sup>“That concept was put forward almost at once at the beginning of the nuclear age that is still the dominant concept of nuclear strategy—deterrence” (Brodie 1978, p. 65).

Almost as soon as MAD was articulated and massive retaliation was invoked, policy makers and intellectuals sought for ways to escape from nuclear stalemate that did not heighten the risk of nuclear war. Schelling (1966) suggested that international politics in the nuclear era involved a process of nuclear brinkmanship. Then US Secretary of Defense Robert McNamara proposed flexible response, a doctrine that was apparently more debated than practiced (Gavin 2012). Others suggested that nuclear weapons were epiphenomenal (Mueller 1988) or largely irrelevant to foreign policy (Tannenwald 2007, 2012).

The application of concepts such as second strike and the nuclear triad were meant to create both more stability and greater flexibility in the conduct of foreign policy. But whether these practices, involving trillions of dollars of national investment, were more effective in achieving deterrence is not yet known. Cold War vertical proliferation, amounting to tens of thousands of nuclear weapons between the United States and the Soviet Union, could have been a coldly calculated product of an arms race or the heated residual of “nuclear alarmism” (Mueller 2009). Again, one must wonder whether nuclear wisdom is empirically grounded and to what degree the actions of nuclear nations are subject to bias or error (Mueller 2010).

So much is not known about the consequences of nuclear weapons that it may be safest to consider existing theoretical research as a critical construct for empirical inquiry, rather than treating carefully reasoned speculation as fact. Researchers including Snyder (1961, 1965), Betts (1987), and Jervis (1990) proposed novel conflict dynamics that are possibly indicative of nuclear status but would benefit from additional empirical assessment. Even when these insights are fundamentally sound, other factors may condition, qualify, interact with, magnify, or diminish a given dynamic. In the next section, we discuss and assess the first stage of this new process of testing and stimulating new theoretical research.

## STUDYING THE SHADOW OF NUCLEAR CONSEQUENCES

The most basic challenge to the empirical analysis of the consequences of nuclear weapons for security is that the direct effects of nuclear weapons have not yet materialized. How does one study the impact of nuclear weapons on war and peace when nuclear weapons have almost never been used? US defense officials often argue that nuclear weapons are “used” every day. The research community has similarly settled on examining observable implications of how nuclear capabilities affect national security and conflict behavior as a substitute for assessing nonexistent nuclear exchanges. Conflict behavior is united by practice, even if it is differentiated by detail (actors, context, intensity, and duration). Nuclear contests appear very likely to be preceded and precipitated by conventional warfare (Powell 2015). Generations of students of military affairs have been reminded of the basic continuity between politics and military violence at all levels (Clausewitz 1976 [1832]). This of course relies on an expectation that the logic of nuclear security may not differ as fundamentally from that of conventional conflict as some may assume (Lieber & Press 2015). Technology may have transformed the means of which Clausewitz wrote, but perhaps not the politics of nations. Of course, the severe data limitation posed by the near absence of nuclear war is a problem common to both qualitative and quantitative empirical research.

The accumulation of information on nuclear issues since 1945 has been most valuable to studies of the causes of nuclear proliferation (e.g., Sagan 1996/1997; Singh & Way 2004; Hymans 2006, 2012; Jo & Gartzke 2007; Solingen 2007, 2012; Fuhrmann 2008, 2009a,b, 2012; Gartzke & Kroenig 2009, 2014; Kroenig 2009a,b, 2010; Bluth et al. 2010; Bleek & Lorber 2014; Brown & Kaplow 2014; Horowitz & Narang 2014; Miller 2014; Way & Weeks 2014; Fuhrmann &

Horowitz 2015; Mehta 2015).<sup>2</sup> There has also been steady growth in the acceptance of quantitative methods by international relations scholars and policy makers. However, as stated above, unprecedented growth in quantitative research on this subject is perhaps a product both of sociological forces within the research community and of improvements in the feasibility of the basic research agenda. New generations of researchers, less bound by traditions of the past, have been eager to engage nuclear security research with the latest techniques. Because quantitative research adds considerably to this field (for a discussion of this issue, see Sagan et al. 2014), it is important now that researchers, in effect, make up for lost time.

We next examine examples of the application of systematic empirical methods to the study of nuclear security. Nuclear deterrence in particular has received considerable attention. Although the enduring debate between nuclear optimists and pessimists (Feaver 1995) has not yet been resolved by quantitative methods, a number of insights have been unearthed. One can divide existing studies along familiar lines, but it is also possible to identify a growing neutral perspective, which argues that nuclear capabilities neither deter nor inflame conflict behavior but instead lead to various effects unanticipated previously.

### **Do Nuclear Weapons Inhibit or Inflame? Deterrence and the Nuclear Spiral**

How revolutionary is the nuclear “revolution,” and in what direction does it point, toward peace or war? Debate has raged for decades over whether nuclear weapons deter or whether they are more likely to touch off conflict spirals (Herz 1951, Jervis 1976). Systematic empirical research has begun to weigh in on this debate. In one of the first studies to apply large-sample quantitative research to the optimist/pessimist nuclear debate, Asal & Beardsley (2007) examine the relationship between conflict severity and the presence and number of nuclear weapons states in a crisis. Actors are expected to exhibit more restraint in crises involving nuclear weapons. Using data from the International Crisis Behavior project, the study finds that crises involving nuclear weapons states are more likely to end without violence. This tendency increases with the number of nuclear actors involved in a crisis.

Two recent studies seem to capture the antipodes of this most important dialectical debate. Kroenig (2013) argues that the appeal of nuclear weapons lies in their utility as tools of influence, not unlike other weapons and even nonmilitary capabilities. Even if nuclear weapons are not deliberately used in anger, states may face a nuclear adversary willing to run risks of nuclear war in an escalated conflict. Kroenig makes theoretical as well as empirical advances: He shows how nuclear superiority can increase the risk a state is willing to run in games of nuclear brinkmanship, allowing it to prevail in interstate crises. Using a dataset of 52 nuclear crisis dyads, Kroenig reports that the state with superior nuclear capabilities is more likely to prevail in these contests. Controlling for nuclear capabilities, he also finds that the magnitude of stakes between actors in a crisis influences crisis outcomes.

Sechser & Fuhrmann (2013, p. 173) find essentially the opposite relationship, concluding that “despite their extraordinary power, nuclear weapons are uniquely poor instruments of compellence.” The authors focus on compellent threats, situations where a state makes a demand involving a change in the status quo. Compellent threats prove effective if a challenger can use force to take or hold territory or if the threat is relatively cheap for the challenger. Neither condition is well suited to the characteristics of nuclear capabilities. With data on roughly 200 compellent threats

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<sup>2</sup>For additional coverage of the proliferation literature, see Sagan (2011). For criticism of some of the early quantitative research on nuclear weapons, see Montgomery & Sagan (2009).

since World War I, Sechser & Fuhrmann find that challengers with nuclear weapons are no more likely to succeed in realizing threats than challengers lacking nuclear capabilities.

Quantifying a dialectic can lead to rapid learning and renewed intellectual progress. However, it can also prove frustrating when similar assessments appear to lead to contradictory conclusions. How are researchers and practitioners to evaluate contrasting findings such as those outlined above? There are several possibilities. First, and perhaps least likely, it may simply be that one side is right and the other wrong. Second, as Sechser & Fuhrmann (2013) argue, it may be that nuclear weapons matter for deterrence and crisis outcomes but not for compellent threats. Third, one source of disparity between these two studies lies in subtle differences between their conceptions of conflict, which lead to differences in their choice of a setting for studying nuclear consequences. As the authors are examining different areas of the conflict spectrum, it may be precisely the peak crises examined by Kroenig (2013) in which nuclear coercive threats are most likely to succeed. Fourth, the coercive value of nuclear weapons—like other aspects of military power (Fearon 1994b)—may be most heavily felt as states select into compellent episodes, making it difficult to observe their effects in the compellent threats that actually take place (Kroenig et al. 2015). Countries possessing nuclear weapons may make challenges that are on average more tenuous or risky and thus are not practical or credible for non-nuclear nations. Finally, much of the action in nuclear security may occur precisely where no one is looking, at relatively low intensities, where confidence that disputes will not escalate to larger contests ensures a denser and more dynamic set of conflict activities.

Snyder's (1961) stability–instability paradox is often acknowledged but seldom implemented in studies of the consequences of nuclear security. Debates over deterrence and the nuclear spiral (“yes it is”/“no it isn’t”) could suffer due to the disparate effects of nuclear weapons at different dispute intensities. In one of the oldest quantitative studies of the consequences of nuclear weapons for war and peace, Bueno de Mesquita & Riker (1982) conclude that nuclear weapons decrease dispute propensity, especially in symmetric dyads (two nuclear powers). The deterrent effect of nuclear weapons is said to increase at higher dispute intensities. However, a variety of estimation issues invite reassessment of this pioneering study. The authors also emphasize the contrasting effects for nuclear symmetry and asymmetry, although the research design makes it impossible to evaluate the effects of initiators versus targets of conflict events.

Reporting almost three decades later, Rauchhaus (2009) finds support for Snyder's stability–instability paradox. Low-level conflict is more frequent for dyads in which at least one state has nuclear weapons. However, war is less likely when both states in the dyad possess nuclear weapons. Yet it is not clear whether these findings reflect deterrence or other, more complex combinations of influences. Using a more suitable estimation strategy, and taking into consideration past patterns of conflict behavior, Bell & Miller (2015) find that wars are no more or less likely in symmetric nuclear dyads, although asymmetric nuclear dyads remain significantly more likely to experience low-intensity disputes. They further find that nuclear-capable states are more likely to be initiators of disputes, a finding they associate with a propensity for nuclear powers to expand the scope of their international interests, rather than reflecting an intensification of conflict with existing enemies.

Gartzke & Jo (2009) also find fault with the prevailing deterrence dialectic. Contrasting claims about the consequences of nuclear weapons rely on different interpretations about how leaders respond to risk, uncertainty, and the balance of power. Deterrence theory argues that proliferation can promote stability and inhibit the use of force, whereas opponents point to hubris, accident, or anger that heightens the risk of war. Nuclear weapons may actually have no net effect on dispute propensity, especially if the tendencies highlighted by nuclear optimists and pessimists tend to cancel one another out. Because states fashion their own bargains, nuclear status should tend to affect the distribution of influence more than the prospects for bargaining failure. Proliferation also

reflects prevailing tensions, biasing upward the apparent impact of nuclear weapons on conflict. Endogenizing the decision to proliferate, the authors find that nuclear weapons increase diplomatic status without much affecting whether states fight.

## **Does the Impact of Nuclear Weapons Vary in Time and Space? Nuclear Conflict Dynamics**

Exploration of temporal and spatial variation can provide additional insight and also add nuance and complexity to our understanding of the consequences of nuclear capabilities. Building on the notion of nuclear status as a dynamic process, research has begun to explore temporal variation in conflict patterns associated with nuclear status. Horowitz (2009) assesses whether the length of time states have nuclear weapons influences their behavior and the behavior of opponents in militarized disputes. Using multiple statistical models and illustrative cases, the author shows that although acquiring nuclear weapons makes states significantly more likely to reciprocate militarized challenges and have their challenges reciprocated, over time, the effect reverses. In contrast to a static understanding of nuclear weapons, this variation in outcomes over time highlights one of the difficulties presented by nuclear proliferation. New nuclear states may have different patterns of conflict behavior than established nuclear powers.

Sobek et al. (2012) examine a similar dynamic that occurs in anticipation of a nation acquiring nuclear capabilities. By beginning the process of proliferating, states telegraph the possible eventual dramatic shift in the balance of power. The interim between exploration and acquisition becomes a period of heightened conflict as declining states face time pressures in addressing disputes, more often leading to violence prior to proliferation by an adversary. The study shows in a cross-national analysis of nuclear weapons programs that the closer nuclear aspirants get to proliferating, the greater their risk of being militarily attacked by other nations. The study does not explore the consequences of these attacks for the nuclear aspirant's success at proliferation (Reiter 2006, Kreps & Fuhrmann 2011), or for the welfare of nuclear nations more generally.

Geller (1990) offers an early quantitative assessment of the contrasting effects of nuclear weapons in symmetric and asymmetric nuclear dyads. Writing a quarter of a century earlier, Geller reports results that are somewhat in tension with those of Bell & Miller (2015), again reflecting the need for further clarity regarding subtle changes in model specification and in sample and variable construction. Nuclear states facing nuclear adversaries exhibit a slight increase in conflict behavior, and non-nuclear states facing nuclear opponents are not significantly less likely to initiate conflict. The net effect of nuclear status is thus minor, but Geller (1990) finds that neither nuclear symmetry nor nuclear asymmetry decreases dispute escalation.

Moving beyond the dyad, Suzuki (2015) uses the machine learning method Random Forests to evaluate the evolution of conflict at the system level in response to a growing number of nuclear powers. Suzuki finds that a higher number of nuclear powers reduces systemic levels of interstate conflict, attributing this to the indirect effects of extended deterrence and a decline in third-party intervention. The study provides a key insight that the impact of nuclear capabilities may well differ within and across nuclear dyads.

## **What Are the Benefits of the Bomb? Winning versus Warning**

One of the most important developments in the systematic empirical study of the consequences of nuclear security involves evidence of what nations stand to gain by possessing the bomb. Weak and often inconsistent findings about the efficacy of nuclear capabilities in reducing the frequency or intensity of conflict have previously led many to the conviction that nuclear weapons must

serve some other purpose besides coercion. Attention turned to the symbolic role of nuclear status (Sagan 1996/1997, Hymans 2006). Several recent studies show how nuclear weapons can generate influence.

In “Winning with the Bomb,” Beardsley & Asal (2009a) argue that success in coercive diplomacy is in part a function of whether nuclear weapons change the perceived costs of conflict. Nations can improve their allotment of a good or convince an opponent to back down and have a shorter crisis as opponents have greater expected costs in a crisis. Noting that nuclear weapons increase the costs of full-escalation scenarios but decrease their probability, they find the impact of nuclear weapons on the expected costs of conflict uncertain. The authors assess crisis outcomes from 1945 to 2000 using the International Crisis Behavior dataset. Their evidence confirms that nuclear actors are more likely to prevail when facing a non-nuclear state. The expected duration of crises in asymmetric directed dyads is substantially shorter than the duration of similar crises for actors in non-nuclear dyads. Nuclear actors in asymmetric dyads are more likely to prevail than states in symmetric nuclear dyads. In a related paper, Beardsley & Asal (2009b) show that adversaries of nuclear-capable states show more restraint in their use of political violence. However, nuclear weapons do not affect overall crisis occurrence. The authors also find that these effects extend to states with nuclear programs.

### **How Do Non-Nuclear States React to the Bomb? Nuclear Externalities**

The enormous destructive power of nuclear weapons implies that the consequences of the bomb are not likely to be limited to intentional or direct effects. The side effects of nuclear security will be both more numerous and more varied than the direct consequences.<sup>3</sup> We discuss several prominent indirect effects, recognizing that other links to nuclear capabilities are likely and that this is an area for future growth in the literature.

Nuclear status can impact the propensity for other nations to proliferate, upsetting the balance of power, threat, or interests. Surprisingly, research to date does not support the popular notion of nuclear contagion (Bleek 2010); countries with enemies that possess nuclear weapons may even be less (not more) likely to proliferate (Singh & Way 2004, Jo & Gartzke 2007). It is possible, therefore, that nuclear weapons may even deter proliferation by other nations. Unraveling the possible existence or direction of contagion is an area deserving additional research.

More attention has been paid to what might be called third-party effects of nuclear status on proliferation. Sechser & Fuhrmann (2014) attempt to explain variation in one particular policy widely thought of as a nonproliferation policy tool: the forward deployment of nuclear weapons. They ask why countries deploy nuclear weapons abroad. Since 1945, more than 20 states have hosted foreign nuclear weapons on their territory, and five countries continue to do so today. Deployments of nuclear weapons on foreign territory have important consequences for international security. Sechser & Fuhrmann develop three broad theoretical frameworks to explain why foreign nuclear deployments occur. Using a new dataset of foreign nuclear deployments between 1945 and 2000, they find that two factors weigh heavily in driving these deployments: the protection of allies and the projection of military power. Interestingly, although it is often argued that deployments contribute to nuclear nonproliferation by increasing the credibility of nuclear security guarantees, thereby discouraging host states from building nuclear weapons, Sechser & Fuhrmann find that nonproliferation

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<sup>3</sup>Fuhrmann & Horowitz (2015) demonstrate a relationship between nuclear weapons and conflict that points in the other direction. Leaders with previous experience as rebels appear more likely to authorize nuclear programs.

motives appear to play little if any role in foreign nuclear deployments. The results carry important implications for our understanding of the causes of proliferation and the sources of nuclear posture.

Fuhrmann & Sechser (2014) take the basic question of the deployment of nuclear weapons further, asking whether deployments of nuclear weapons meaningfully add to the deterrent effect of nuclear promises in the form of alliance ties. Formal nuclear alliance commitments are found to have a significant effect in deterring aggression against allies. In contrast, the authors find no evidence that nuclear weapons deployments significantly improve deterrence success. These findings pose a conundrum for policy work on nuclear posture, if indeed the location of nuclear weapons does not much impact deterrence.

Bleek & Lorber (2014) explore the related issue of nuclear alliances. They seek to understand whether the extension of nuclear security guarantees from nuclear-armed patrons serves to dissuade recipients from exploring, pursuing, and acquiring independent nuclear arsenals. As they point out, conclusions from previous research have been mixed, with some scholars finding that states in a defense pact with a nuclear power are less likely to proliferate and others finding no effect. Bleek & Lorber conduct a careful forensic analysis of the previous research to uncover the reasons for this discrepancy and, using improved data, they report a robust negative relationship between nuclear security guarantees and a nation's tendency toward nuclear proliferation. This suggests the possibility that policy makers in nuclear-armed states may be able to extend the nuclear umbrella to other states in order to discourage nuclear proliferation.

In a closely related article, Reiter (2014) also inquires into the relationships between third-party security commitments and nuclear proliferation. Reiter develops a theory connecting security commitments and the decision to acquire nuclear weapons in order to determine when and why security guarantees appear to deter proliferation in some cases but not others. In a threatening environment, third-party security commitments can reduce a state's fear of abandonment in the event of war and weaken its motive for acquiring nuclear weapons. However, a threatened state may reject at least some kinds of security commitments, such as foreign deployed nuclear weapons, if it fears that such commitments increase the risk of being dragged into a war that the state would like to avoid. The article looks at three kinds of security commitments: alliances, foreign deployed nuclear weapons, and foreign deployed troops. In quantitative tests that speak directly to the research conducted by Fuhrmann & Sechser, Reiter finds strong evidence that foreign deployed nuclear weapons reduce proliferation motives, only very limited evidence that alliances reduce proliferation motives, and no evidence that foreign deployed troops reduce proliferation motives. Reiter also presents supportive qualitative evidence that helps explain why alliance ties sometimes do not prevent proliferation.

Building on this research, Kroenig (2016) examines a question at the center of US nonproliferation policy. Many policy makers argue that the US nuclear arsenal is an important determinant of proliferation decisions in other states and that the United States can dissuade nuclear proliferation elsewhere by reducing the size of its own nuclear arsenal. Contrary to the received wisdom in policy circles, he maintains that state decisions on nuclear nonproliferation issues are driven by a range of other security, economic, and political factors and, once these considerations are taken into account, there is little if any remaining variance to be explained by US nuclear posture or Washington's commitment to nuclear disarmament. Using a dataset on US nuclear arsenal size from 1945 to 2011, he finds no evidence of a relationship between the size of the US arsenal and any of the following: the exploration, pursuit, or acquisition of nuclear weapons by other countries; the provision of sensitive nuclear assistance to states that do not have nuclear weapons; and voting on nonproliferation issues in the United Nations Security Council. The findings contribute to our understanding of how the nuclear posture of nuclear powers affects proliferation elsewhere and

gives us reason to believe that Washington's efforts to use disarmament as a means of advancing nonproliferation goals might not succeed.

### **Does More Make a Difference? Force Structure, Force Posture, and Vertical Proliferation**

Initial attempts to quantify the consequences of nuclear capabilities relied heavily on nominal nuclear status as the critical indicator ("existential deterrence"). These studies do not, therefore, help us understand how variation in nuclear capabilities among nuclear-armed states contributes to, or possibly undermines, various effects of nuclear status. Recent research has begun to unpack nuclear status, looking at superiority (Kroenig 2013), counts of nuclear arsenal sizes (e.g., Gartzke 2015), and more detailed evidence of a nation's nuclear capabilities. Although the process of unraveling nuclear status is just beginning, it is particularly promising.

Narang (2013) argues for increased attention to nuclear force posture as a critical variable determining nuclear consequences. In particular, different deterrence postures should produce different qualities of deterrence, especially with regard to less established nuclear powers. Narang shows that a nuclear posture of asymmetric escalation uniquely deters conflict initiation and escalation. Not only do small arsenals have little deterrence success, but even assured retaliation postures fail to deter intense conventional conflict. Narang's findings imply that the benefits of deterrence are distributed unequally across nuclear powers, and that states may need to do more than simply acquire nuclear weapons to successfully deter conventional attacks (see also Kapur 2007, Narang 2010).

One approach is to identify details of a nation's overall nuclear capabilities, its nuclear force structure. This is crucial to better understand how the qualities (as opposed to quantities) of nuclear capabilities influence conflict. Gartzke et al. (2014) examine nuclear force structure, focusing in particular on platform diversification. They inquire why some states develop many platforms to deliver nuclear weapons against their opponents, whereas others develop only a few. The authors offer a portfolio theory of nuclear force structure, positing that states seek diverse capabilities for nuclear deterrence. In a subsequent study, Gartzke et al. (2015) find that nuclear platform diversification does indeed improve deterrence success, even when considering other possible determinants of deterrence, such as arsenal size and the utilization of strategic ballistic missile submarines.

### **CHALLENGES FOR SYSTEMATIC EMPIRICAL RESEARCH ON NUCLEAR CONSEQUENCES**

Efforts to apply systematic empirical analysis to understand the effects of nuclear proliferation have only begun. There remain several challenges. It is of course difficult to make inferences based on a limited number of observations (the small-N problem). In particular, there is a danger, given the small samples in nuclear security research, that true hypothetical claims about the world will be rejected. It should be noted that this problem is faced by all empirical approaches to the study of nuclear security. Given normative biases intrinsic to hypothesis testing, the tendency may be to increase the incidence of type II errors rather than type I errors. Yet, as has often been said, the absence of evidence is not evidence of absence; researchers should be attentive to the possibility that claims about the role of nuclear weapons that cannot be demonstrated at present may become statistically significant in the future when more and better data become available.

A second, more encompassing problem has to do with endogeneity. Almost every behavior of interest is endogenous; the "chickens" are as likely to be responsible for "eggs" as vice versa.

The nuclear security environment is notably strategic. States choose to develop nuclear weapons because of the actions of other nations, even as the expectations of other countries condition proliferation decisions, and so on. In the context of deterrence in particular, almost any theoretical expectation is defensible, depending on actors' time horizons and available information (Nalebuff 1986, 1991). Differences in the details of action and reaction between nuclear states and their adversaries imply different outcomes, depending on whether researchers' predictions are robust to revelation by actors themselves. On the one hand, nuclear weapons may not appear to deter if the adversaries of nuclear powers are intimidated at a stage prior to overt threats or reactions—contrasting the effects of general versus immediate deterrence (Fearon 1994a). On the other hand, nuclear-capable states might well overstep, or non-nuclear opponents might fail to be sufficiently cowed by the different dynamics of nuclear versus non-nuclear deterrence. Similar dynamics could also lead to contrasting outcomes if nuclear states and their adversaries have different goals or information, or if nuclear powers vary in their relationship to the status quo.

All of these factors encourage humility, not least among researchers applying systematic methodologies.<sup>4</sup> The central paradox of nuclear security is precisely that normatively desirable outcomes limit variation. “Good news” has meant both that nuclear holocaust has been avoided and that we cannot be sure how to best avoid it in the future. Yet, inference cannot be improved by reducing how much one can glean from available observations; systematic approaches make the most of what we observe. As in other areas of inquiry, efforts to combine careful theory and evidence are bound to yield the greatest benefit. The basis for comparison is not “being right” but increasingly close approximations of not being wrong.

Political science has made great strides in recent years in absorbing, applying, and developing critical improvements in inference. Ultimately, the best inferences are achieved through experimental techniques. Employing a survey experiment of US households, Press et al. (2013) show that the American public is quite willing to support the use of nuclear weapons if they are the most effective tool for the job at hand, calling into question previous notions of an unshakeable nuclear taboo (Tannenwald 2007). Although there are other areas within the nuclear security arena that may be amenable to experimental approaches, for the most part empirical approaches to nuclear consequences will still depend on observational data. The task before researchers is thus a compromise between ideal and real experimental conditions, where the best available approach to analysis is second best. At the same time, there remains considerable potential to advance observational research, and to build in particular on ties between theory and evidence.

## AVENUES FOR THE ADVANCEMENT OF THE LITERATURE

The initial steps outlined in the review above are promising and serve as a proof of concept for the larger research agenda on systematic approaches to nuclear security. Much remains to be done in order to realize the larger potential of this literature, however.

Researchers must develop new data and operationalizations that will tie their tests more closely to real-world questions and concerns. Previous research measured the nuclear weapons status of states as a dichotomous variable (Gartzke & Kroenig 2009). Regardless of whether the possession of nuclear weapons was treated as the independent or dependent variable, it was coded only as the presence or absence of at least one nuclear weapon. In contrast, as Montgomery & Sagan (2009) point out, many of the most important questions in the field of nuclear studies concern numbers

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<sup>4</sup>Douglas & Lanoszka (2015) offer a cautionary tale about inference in the nuclear domain. A relatively small number of overlapping observations, collinear variables, and indistinct concepts invite ambiguous inferences.

and types of nuclear weapons and variations in nuclear policies. As discussed above, the literature has gone to great lengths to collect and analyze more disaggregated data on nuclear capability. Indeed, there is a case to be made that this is one area where systematic research on nuclear conflict has already advanced beyond the larger field of conflict studies, as existing measures of nuclear capabilities and power are already more nuanced and disaggregated than the Composite Index of National Capability scores used to proxy military power in the standard literature. Still, there remain a number of gaps between existing evidence and key issues in the academic and policy communities. We discuss several opportunities for future research on the consequences of nuclear weapons below.

One critical task involves developing disaggregated data that can address a variety of issues that cannot yet be subjected to empirical analysis. Relatively little attention has been paid to other elements of what are inevitably complexes of technologies and weapons systems. Nuclear weapons require platforms for launch or deployment. Often, these involve ballistic missiles (Mettler & Reiter 2013), and accordingly civilian space programs are often strongly associated with attempts to acquire nuclear weapons (Way & Early 2012). They also depend heavily on intelligence, surveillance, and reconnaissance (ISR) platforms for threat warning, targeting information, guidance, and command and control (Early 2014, Long & Green 2015). Almost no attention has been focused on support, command and control, and the policy apparatus of nuclear capabilities. Moreover, before states develop nuclear weapons, they enter a period of nuclear latency (Fuhrmann & Tkach 2015, Volpe 2015), which might have implications for nuclear nonproliferation and conflict behavior.

Researchers can also disaggregate the impact of nuclear capabilities without directly disaggregating nuclear capabilities. Nuclear nations are likely to vary in how they use nuclear arsenals for deterrence, conflict, or influence, depending on factors like satisfaction with the status quo, institutionalization, and integration within the international community. Democracies are more peaceful, at least in pairs, than other regime types, but what is the interaction between regime type (monadically, dyadically) and nuclear status? Are status quo nuclear nations more likely to deter successfully or do the effects of nuclear weapons remain complex and somewhat inscrutable, regardless of the disposition of prerogatives of nuclear nations? Perhaps the seemingly contradictory findings to date on nuclear possession and conflict propensity are driven in part by systematically different behavior from status quo and revisionist nuclear powers.

There is also room for more detailed studies of nuclear force structure, or nuclear posture, and their respective effects on stability and conflict. One of the features of nuclear weapons may be that they are relatively immune to distance; even distant nuclear weapons can be relevant in the local balance of power because of their ability to move across great distances quickly. Studies of deterrence that stress the local balance of power (Huth 1988, 1990) may find that nuclear weapons are less subject to the loss-of-strength gradient than other forms of military power (Boulding 1962). Geography would also imply the converse: nations hosting nuclear weapons are potential targets in a conflict, regardless of whether they are directly involved in the underlying dispute (Gartzke & Tago 2012).

The need to explore policy implications of nuclear weapons is likely to be an ongoing empirical process. As Great Britain nears its final decision on the successor to Trident, for example, questions about the efficacy of an exclusively seaborne nuclear deterrent loom large. Controversy also rages about vertical proliferation and “minimal deterrence.” It is not known, for instance, why the superpowers possessed arsenals of tens of thousands of nuclear warheads in the 1980s, only to reduce their stockpiles several fold since then. At the same time, middle nuclear powers have adopted much more conservative nuclear strategies, and the research and policy communities do not clearly understand the reasons for this enormous variation in nuclear arsenal size (Fravel & Medeiros 2010).

There are numerous other opportunities to clarify new or ongoing debates or to address controversies in the literature, including how new technology will affect old nuclear dynamics. For example, Lieber & Press (2006) suggest that technological innovations in recent years may have moved the United States in particular to a point where adversaries lack a secure second-strike deterrent to protect against unilateral American attack. Kroenig & Volpe (2015) have argued that 3-D printing has lowered barriers to the supply side of proliferation and could induce a future additive manufacturing-enabled cascade of nuclear proliferation. Growing dependence on cyberspace may also create new vulnerabilities for nuclear forces (Gartzke 2016). These vulnerabilities will by their nature be much less transparent than nuclear weapons themselves.

The question of when precision, arsenal size, and other variables created an environment ripe for moving from counter value to counter force, where nations possess or lack certain kinds of deterrent capabilities, and the effects of these changes are all areas that merit attention and may be amenable to new empirical research. The broader topic of cross-domain deterrence deals with many of these emerging issues (Gartzke & Lindsay 2016).

Another set of questions wide open for future research is on how nuclear weapons affect domestic politics. To date, nuclear security research has been conducted squarely within the international relations subfield, but students of comparative politics may want to begin to assess how the pursuit, acquisition, and brandishing of nuclear weapons affect government favorability ratings, party support, regime stability, and a host of other domestic political variables. Scholars have argued that states pursue nuclear weapons for domestic political reasons (Sagan 1996/1997), but do leaders of nuclear nations actually derive the anticipated domestic political benefits?

A final area where gains could be greatest, and most easily obtained, is in the application of multiple-method approaches and increased interaction among researchers with varied skill sets and interests. The study of nuclear security is best addressed through a diversity of approaches, especially given that all existing methods possess deficiencies. We close with an appreciation for a vigorous literature that has made great strides in a short period of time and shows considerable promise for the future.

## DISCLOSURE STATEMENT

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