Conflicts that Leave Something to Chance: Establishing Brinkmanship through Conventional Wars

Peter Schram*

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Abstract

The development of nuclear weapons added a new dimension to conventional conflict: the possibility that it could inadvertently escalate into a nuclear exchange. How does this relationship between conventional war and nuclear escalation shape deterrence? I present a formal model of deterrence and arming. The novelty here is that investing in conventional capabilities has a direct effect on the balance of power and an indirect effect on conflict duration and the likelihood of an accidental nuclear exchange. I find that introducing the risk of nuclear escalation may require greater conventional force postures for deterrence, thus lowering welfare in the absence of nuclear war. I also find the nuclear era will be more peaceful, but when conflicts occur, they may be more aggressive and decisive. These results (and others) offer insight into the difficulty of substituting nuclear weapons for conventional arms, and into the Soviet response to the 1956 Hungarian Revolution.

*Assistant Professor, Department of Political Science, Vanderbilt University. `peter.schram@vanderbilt.edu`
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"*Discussions of troop requirements and weaponry for NATO have been much concerned with the battlefield consequences of different troop strengths and nuclear doctrines. But the battlefield criterion is only one criterion, and when nuclear weapons are introduced it is secondary. The idea that European armament should be designed for resisting Soviet invasion, and is to be judged solely by its ability to contain an attack, is based on the notion that limited war is a tactical operation. It is not. What that notion overlooks is that a main consequence of limited war, and potentially a main purpose for engaging in it, is to raise the risk of larger war.*"

— Thomas C. Schelling, *Arms and Influence*, 1966

1 Introduction

The defining feature of international politics since 1945 has been the absence of direct great power conflict (Gaddis 1986). To explain this historical anomaly, some scholars classify this "long peace" as the "nuclear peace," where the fear of a nuclear exchange prevents significant conflict among great powers (Waltz 1981; De Mesquita and Riker 1982; Mearsheimer et al. 2001). How the nuclear peace functions in practice is subtle. It is not as if states can credibly deter all revisionist behavior through the threat of a nuclear first strike. After all, unless it is facing an existential threat, no state would ever intentionally launch a strategic nuclear strike against an opponent with a credible second strike capability, as doing so would be tantamount to suicide. And the existence of nuclear weapons does not prevent states from fighting conventional wars. In theory, states with nuclear weapons could forgo them and fight conventional conflicts with one another, just as they did before the advent of nuclear weapons. Instead, what preserves the nuclear peace is the threat of unintended escalation (Schelling 1980, 1966; Powell 2015). In the nuclear era, any conventional conflict is unstable and could result in a nuclear exchange. Thus, proponents of the nuclear peace suggest that the near absence of large-scale, direct conventional conflict between nuclear states stems from a new and frightening feature of conventional conflicts: they could accidentally spiral out of control (Snyder 1965; Jervis 1976; Schelling 1966; Powell 2015).

While the nuclear peace can be rationalized within the current theoretical framework connecting conventional conflict to nuclear escalation, other salient features of the nuclear era are more difficult to understand. Scholars have theorized that the nuclear era should be a period of limited wars and restraint, where deterrence becomes easier to achieve (Snyder 1965; Waltz 1981; De Mesquita and Riker 1982; Mearsheimer 1984, 1990; Powell 2015). Yet the nuclear peace has come at exceptionally high cost. During the Cold War, both the Warsaw Pact and NATO spent enormous sums on conventional capabilities—preparing for a conventional assault in Europe by their opponents (Facer 1985; Karber and Combs 1998; Gaddis 2005). Perhaps in theory the nuclear era should be a period of restraint, but neither side expected its opponent to actually use such restraint, and they armed themselves accordingly. Additionally, while there have undoubtedly been instances of nuclear-armed states exhibiting restraint in crises (e.g., the Kargil War), the Soviet Union also showed little restraint in repressing revolutionary movements within its sphere of influence in Eastern Europe. Furthermore, India recently (2019) passed the Jammu and Kashmir Reorganization Bill, which significantly increased Delhi's control of the region, then flooded the region with solders and police forces to prevent unrest and escalation. What then explains the nuclear era, where peace largely persists between nuclear powers, there is an extensive conventional force buildup, and international crises can feature either restraint or aggressive military maneuvers?

To better understand force posture and conventional conflict in the nuclear era, we must follow Schelling's insight: conventional force posture shapes both the conventional balance of power and the risk of a nuclear war. In this paper, I model a deterrence setting between two states in a crisis over an asset. The asset in dispute is important to the two actors, but not important enough for either state to deliberately launch a strategic nuclear first-strike to deny an opponent the asset (i.e. this is not a matter of existential importance). Instead, states may willing to fight a conventional conflict over the asset, but unlike in other models of deterrence, here the conventional conflict could accidentally or inadvertently escalate to a strategic nuclear exchange (Carter 2010; Gurantz and Hirsch 2017; Spaniel 2019*b*; Yoder 2019*b*; Baliga, De Mesquita and Wolitzky 2020; Di Lonardo and Tyson 2022). The most unique feature of this model is that building a robust conventional force posture has a first-order effect on the balance of power and deterrence, and, should a conventional conflict arise, second order effects on conflict duration.

Using this model, I establish two key theoretical results. First, I find that the risk of inadvertent nuclear escalation may require states to increase their spending on conventional weaponry, compared to what they would spend in a world without nuclear weapons. This means that even if the nuclear era never escalates to a nuclear exchange, there may be a welfare loss for the states involved. Why? When introducing the feature that a conventional conflict could result in a nuclear exchange, all actors will do worse in a conventional-but-now-potentially-nuclear conflict, which will make a defender less willing to fight when challenged. In turn, this can undercut the defender's deterrent threat against a challenger, thus undermining deterrence and enabling challengers. In response to this added risk, to remain willing to fight, the defender must find a way to do better in the conventional conflict, which can be achieved through a more robust initial force posture—that is, one which will make the defender more likely to win should the conflict end conventionally. This finding matters because it adds a new dimension to previous discussions of the costs and benefits of nuclear weapons. Previous research and the debates between nuclear optimists and pessimists suggest that the nuclear era may be a more peaceful era, but also one with more destructive wars and riskier peace (Sagan and Waltz 2003; Kydd 2019). In addition to these trade-offs, this paper suggests that states may have to invest more in costly, conventional forces in the nuclear era in order to maintain their deterrent threat.

Second, I also find that actors in the nuclear era will sometimes demonstrate restraint, but at other times will act more aggressive and decisive than they otherwise would. This duality can be explained based on the logic of how nuclear risk is generated within a conventional conflict. Conventional conflicts could become strategic nuclear exchanges through accidents, decentralized decision-making, or inadvertent escalation (Sagan 1994; Posen 2014). Across all these mechanisms, the time spent in conflict is critical. When conflicts between nuclear powers are short and decisive, there are fewer opportunities for unintended escalation leading to a nuclear exchange; if a conventional conflict in the nuclear era is a war of nerves similar to "rocking the boat" (Schelling 1966), then the shorter the time spent rocking, the less likely actors are to get soaked. Nuclear risk incentivizes actors to take steps that will make a conflict more decisive, which can lead to more or less aggressive force postures (whichever leads to shorter conflicts).

To the best of my knowledge, these two theoretical results are new. However, findings like these are only valuable insofar that they explain real world behavior that the existing state-of-the-art theories cannot fully rationalize. The finding that nuclear risk may incentivise actors to act more decisively in a conflict offers insight into the Soviet repression of the 1956 Hungarian Revolution and recent (2019) Indian activity in Kashmir. In both cases, rather than act with restraint (as research like Powell (2015) would predict), actors took decisive actions to quickly resolve the conflicts; the theory here suggests that these actors may have behaved aggressively due to the nuclear risks of becoming mired in a protracted conflict. And, the finding that nuclear risk is not a clear substitute for conventional forces offers insight into the challenges the Eisenhower Administration faced attempting to replace an expansive conventional force posture with strategic nuclear weapons. Over the course of his administration, Eisenhower experienced a series of international deterrence failures, and his defense budget shrank only slightly. The theory presented here offers a micro-foundation for how a nuclear era with fewer realized conflicts may perversely require a greater conventional force posture to maintain deterrence.

This paper identifies a series of other results. It offers a new formal theoretical grounding for the nuclear peace. It offers some additional support for (and important qualifiers to) the stability–instability paradox. It describes how increasing nuclear instability can (perversely) lead to more instances of deterrence failure. It discusses how aspects of the nuclear revolution beyond strategic nuclear weapons—like nuclear submarines and tactical nuclear weapons—shape our understanding of the nuclear peace and deterrence. And it establishes how, in an incomplete-information environment, using conventional force posture to signal resolve can lead to fewer instances of conflict and a lower risk of a nuclear exchange relative to signaling with nuclear risk (as examined by Powell (2015)).

This paper is related to others that consider crises where multiple levels of conflict are feasible (Lanoszka 2016; McCormack and Pascoe 2017; Spaniel and Malone 2019; Baliga, De Mesquita and Wolitzky 2020; Kenkel and Schram 2021; Guenther and Musgrave 2022; Joseph 2023; Gibilisco 2023). The key difference here is that, because this paper considers accidental or inadvertent nuclear escalation, escalation from the lower (conventional) to higher (nuclear) level is probabilistic. This paper is most similar to Powell (2015), which also considers nuclear risk stemming from a conventional conflict. However, Powell applies a different theoretical grounding to how nuclear risk is generated, and his results generally suggests that actors will behave with restraint; this means that Powell can explain cases like the Kargil War, but not the Hungarian Revolution and India's recent activity in Kashmir (as discussed further in Sections 3.2 and 8.2). Additionally, this paper is naturally related to the topic of nuclear proliferation (Bas and Coe 2012, 2016; Lanoszka 2018; Spaniel 2019*a*), but here it is already established that both sides possess a nuclear capability.

2 On Conventional Force Posture, Conventional Conflict, and Nuclear Risk

I assume that there is a non-monotonic (increasing-then-decreasing) relationship between the defender's conventional force posture and nuclear escalation risk. I make this assumption based on past scholarship that I detail below. To summarize, the non-monotonic structure is based on three relationships which connect conventional arming to nuclear risk. First, when the defender increases its conventional force posture, this can increase or decrease conventional military parity between the challenger and defender. Second, should a conventional conflict arise, closer conventional force parity between disputants will result in a more protracted conventional conflict. Third, longer conventional conflicts will generate greater risks of nuclear escalation. Together, these imply that increasing one's conventional force posture could make conflict more or less decisive, which could lead to less or more nuclear risk (respectively).

Adding conventional forces can increase or decrease military parity. This first relationship is mechanical. One side's adding conventional forces may narrow the gap between two sides—when the defender's capabilities approach the challenger's capabilities—or widen it—when the defender's capabilities surpass the challenger's capabilities.

Closer military parity between actors results in longer conflicts. If military parity is low, then a decisive war or a rapid surrender is more plausible. On the other hand, if militaries are more evenly matched, then neither side has an immediate reason to stop fighting. Because closely matched militaries will trade battle victories and defeats, war between them will be less informative or less clearly decisive, which will incentivize them to continue fighting. This logic is illustrated in a series of theoretical models (Smith 1998; Filson and Werner 2002; Langlois and Langlois 2009, 2012; Slantchev 2004), and is echoed by empirical findings (Bennett and Stam 1996, 2009; Slantchev 2004; Krustev 2006; Chiba and Johnson 2019).[1]

Longer conflicts generate a greater likelihood of a nuclear exchange. Conventional conflicts could escalate to a nuclear exchange through several mechanisms. First, it could come about entirely through accident. In any complex system, including missile detection or early warning systems, system failures are possible (Sagan 1994, 2020; Sagan and Waltz 2003; Perrow 2011). When states are at war, there is heightened risk that a faulty signal could be interpreted as an act requiring a nuclear response (Sagan 1994). Nuclear escalation could also arise through the course of conventional conflict operations. Whether through mechanical error (a malfunctioning GPS), human error (misread maps), agency problems, or the fog of war, sometimes soldiers or operators take actions beyond what a rational, unitary decision-maker would want, which could make a crisis over an auxiliary issue seem existential and thus necessitating escalation (Sagan 1994; Posen 2014; Lin-Greenberg 2023). Also, in a protracted conventional war, states may target their opponent's communication or command-and-control infrastructure, which could inadvertently undermine the targeted state's second-strike capability, which in turn might risk nuclear escalation (Posen 2014).[2] While we typically ascribe these risks to newer nuclear states, all states implement some degree of decentralized decision making within crises or conflicts that can result in some risk of accidental escalation (Feaver, Sagan and Karl 1997; Sagan and Suri 2003). Recent research suggests this dynamic may be further exacerbated by how states respond to cyber capabilities and vulnerabilities (Bahney and Sopher 2023; Schneider, Schechter and Shaffer 2023).

Across all these different ways a conventional conflict could turn nuclear, time is an underlying factor. When conventional conflicts between nuclear powers are short and decisive, there are fewer chances or reasons for system failures, overambitious operations, or the targeting of command-and-control infrastructure. But as such conflicts drag on, the likelihood of any of

[1] This result does not always hold. For example, Bueno de Mesquita, Koch and Siverson (2004) observes this relationship it in democratic dyads, but finds no relationship in non-democratic dyads. To the best of my knowledge, no research identifies a negative relationship.

[2] In the logic of mutually assured destruction, an actor on the verge of losing its second-strike capability might undertake dramatic, escalatory steps in an attempt to degrade its opponent's first-strike capability and thus preserve its own second-strike capability.

these errors, and thus the possibility of a strategic nuclear exchange, increases. Taking these considerations together, if a defender arms or deploys a conventional force posture in such a way as to make the conflict one-sided and decisive, there will be little risk of a nuclear escalation. But if the defender's force posture lends itself to a prolonged conventional conflict, then there will be greater risk of a nuclear exchange.

3 Model

3.1 Game Form and Assumptions

Two players, a challenger (C) and a defender (D), are in a deterrence game with complete information. The game order is as follows.

1. D selects a conventional force posture (or arming level) that determines $p \in [p_0, p_1]$, which is D's likelihood of winning in a conventional conflict. I assume $0 < p_0 < p_1 < 1$.

2. C selects whether to challenge or not. If C does not challenge, the game ends with C receiving payoff 0 and D receiving payoff $v_D - K(p)$, where $K : \mathbb{R}_+ \to \mathbb{R}_+$ is D's costs from the conventional force level. I assume $K(p_0) = 0$, and K is continuous and increasing in p. If C does challenge, the game moves to the next stage.

3. D selects whether to acquiesce or escalate to conflict. If D acquiesces, C receives payoff v_C and D receives payoff $-K(p)$. If D escalates to conflict, then both states receive their conflict payoffs (described below).

Conflict is a stochastic process that will end in one of three ways: C wins a conventional victory, D wins a conventional victory, or there is a catastrophic nuclear exchange. Let $n \geq 0$ denote the hazard rate for the termination of the conflict through a nuclear exchange. Essentially, n represents the "nuclear instability" of a conflict; n takes on greater values when C or D are more accident prone (Sagan 1994), have decentralized or automated the nuclear launch decision (Feaver, Sagan and Karl 1997; Schneider, Schechter and Shaffer 2023), have a more expansive nuclear arsenal, or are fighting near critical nuclear infrastructure (Posen 2014). The case when $n = 0$ is particularly important: this is when there is no risk of nuclear escalation—that is, it represents conflict before the nuclear revolution. Following the logic discussed in Section 2, I let $\frac{\alpha}{p(1-p)}$ denote the hazard rate for the termination of conflict through conventional means. The choice variable p was defined above; for conflicts between lopsided adversaries ($p \approx 0$ or $p \approx 1$) the hazard rate is large, which is consistent with one-sided conventional conflicts ending quickly (Slantchev 2004; Bennett and Stam 2009). $\alpha > 0$ is a scaling parameter that grants more flexibility to the conventional conflict hazard rate.[3] Together, this means that $h(p) = n + \frac{\alpha}{p(1-p)}$ is the hazard rate for conflict ending, $n/h(p)$ is the likelihood that conflict ends in a nuclear exchange, $\frac{\alpha}{h(p)p(1-p)}$ is the likelihood that conflict ends conventionally, and $\frac{1}{h(p)}$ is the expected time to conflict termination.[4]

If the game ends with a nuclear exchange, D's and C's expected payoffs are $-N_D \in \mathbb{R}$ and $-N_C \in \mathbb{R}$, respectively. If the conflict ends conventionally, D wins with probability p, and C wins with probability $1-p$. Regardless how conflict ends, by fighting, actors accrue conventional conflict costs at the rate $c_D \geq 0$ and $c_C \geq 0$, respectively.

C's expected utility from conflict is

$$\frac{n}{h(p)} * (-N_C) + \frac{\alpha}{h(p)p(1-p)}((1-p)v_C) - \frac{c_C}{h(p)},$$

and D's is

$$\frac{n}{h(p)} * (-N_D) + \frac{\alpha}{h(p)p(1-p)}(pv_D) - \frac{c_D}{h(p)} - K(p).$$

Figure 1 illustrates the likelihood of a nuclear exchange and D's expected utility without arming costs, $K(p)$, from a conflict for a range of possible p's under one set of parameters. First, consider the likelihood of nuclear exchange (the solid line in the figure). For small or large conventional arming levels ($p \approx 0$ and $p \approx 1$), $h(p)$ becomes large and $h(p)p(1-p)$ becomes small; thus, when the conventional arming level leads to an unbalanced or one-sided conventional conflict, there is little risk of a nuclear exchange ($\frac{n}{h(p)}$ is smaller) and there is a greater likelihood of the conflict ending conventionally ($\frac{\alpha}{h(p)p(1-p)}$ is greater). In a more balanced conventional conflict ($p \approx \frac{1}{2}$), there is greater risk of nuclear exchange and a (relatively) lower likelihood the game ends with a conventional victory or defeat.

Now consider D's payoff from conflict without arming costs (the dashed line). As p increases from 0 to roughly 0.35, the conflict becomes more protracted, and the increasing risks of a nuclear exchange reduce D's payoff. Then, for p values greater than 0.35, the defender continues becoming more likely to win the conflict and the nuclear risk increases more slowly and then eventually decreases; together, this means D's utility is increasing in p until reaching p_1.

[3]Without α, the conventional conflict hazard rate $\frac{1}{p(1-p)}$ is always 4 or more, which limits how costs are accrued.

[4]Note I am not treating conventional conflict as a continuous-time, war-of-attrition game where states can choose to drop out at any time; rather, I treat it as a reduced-form process.

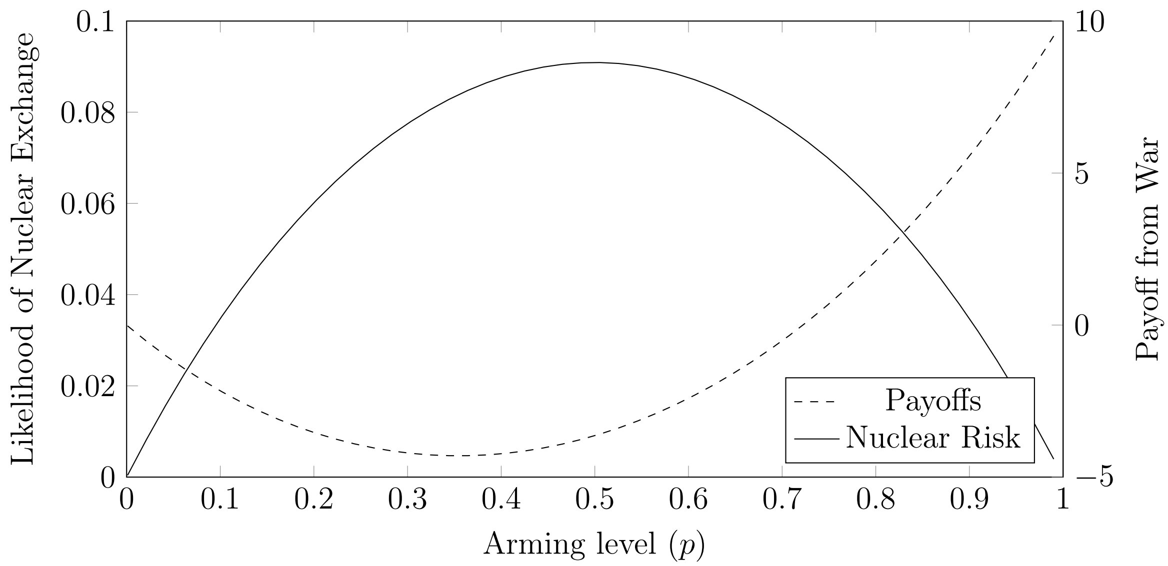

Figure 1: Nuclear risk and payoffs with the costs of arming excluded. Parameters for this figure (and all other figures) are in the Appendix.

3.2 Comments on Model Assumptions

This is a deterrence model, like Powell (2015), Gurantz and Hirsch (2017), Di Lonardo and Tyson (2022), Baliga, De Mesquita and Wolitzky (2020), and others. For a version of the game with bargaining, see Section 7.2. The model setup is most similar to Powell (2015), but differs in several key respects. First, in the model presented here, nuclear risk in a conventional conflict is determined indirectly through the defender's arming level. In contrast, in Powell, the defender is able to directly, publicly, and credibly manipulate the level of nuclear risk within a conventional war without altering its likelihood of winning in the conventional war.[5] While the model of Powell is groundbreaking, it includes several strong assumptions that may not apply to all settings. For example, Powell assumes it is possible to publicly and credibly manipulate the likelihood of a nuclear exchange within a crisis. Practically, doing so would be subjected to "cheap talk" concerns, as a defender may want to signal that they have implemented a high-risk system to deter challengers when, in reality, they have not. Placing conventional forces, as the defender does in my model, is more visible and less subject to this kind of bluffing.

Second, in Powell, whenever one actor adds additional conventional forces to a conflict, this *always* leads to a greater risk of escalation. Unlike in the model presented here, Powell does not consider the possibility that undertaking a rapid and decisive deployment could potentially reduce the probability of a nuclear exchange by preventing a protracted affair.

[5]Formally, after a challenger selects some level of arming, p, the defender selects function $r(p)$. p denotes the likelihood the C wins in a conventional conflict, and $r(p)$ denotes the likelihood the conventional conflict escalates to a nuclear exchange.

The modeling choices in this paper were made in an attempt to best represent our scholarly understanding of conflicts over non-existential issues in the nuclear era. In adopting these choices, I establish a series of results suggesting that actors may arm more (Remark 1), fight harder (Remark 4), and signal more effectively (Remark 7) than what is established in Powell (2015), and below I describe how these insights offer more nuance into substantive cases in the nuclear era. However, some readers may prefer some of the modeling choices made in Powell (2015), and I address these concerns in the following way. First, if readers prefer assuming that nuclear risk is monotonically increasing in the selected conventional force posture, my model can support this assumption;[6] all remarks below will still attain, excluding Remark 4, which I discuss more below. Second, if readers believe that the defender can also manipulate nuclear risk, I discuss in Section 7.1 a version of the model where the defender manipulates both conventional arming and nuclear risk; again, similar results attain. Lastly, while the results here are robust to modifications to make the model more like that in Powell, these results are distinct from what is presented in Powell).

This paper also has benefited from decades of iterations of models of nuclear deterrence (Schelling 1980; Nalebuff 1988; Zagare and Kilgour 1993; Powell 1989, 2003; Bahney and Sopher 2023). I will not cite the entire set of studies on nuclear deterrence but refer readers to several excellent reviews, including Jervis (1979), Huth (1999), Quackenbush (2011) and Gartzke and Kroenig (2016). Additionally, the model integrates features from the formal literature on endogenous transgressions and deterrence (Fearon 1997; Debs and Monteiro 2014; Gurantz and Hirsch 2017). Of course, nearly every model cited above considers only two types of outcomes: war and peace. This paper is related to a new branch of research considers conflict that can be more multifaceted (Tarar 2016; Powell 2015; Lanoszka 2016; Coe 2018; Yoder 2019*a*; Spaniel 2019*a*; Joseph 2020; Baliga, De Mesquita and Wolitzky 2020; Schram 2021*a*,*b*). The key difference from earlier work is that this paper considers initial force placement as driving the likelihood of conflict escalation.

Important scope conditions apply to the results. The model is well suited to describe crises between two nuclear-armed states, where the crisis is over not-existentially-important issues, and where nuclear escalation risk is generated through conventional conflict. This covers a range of settings. The model can capture settings where there is low-but-not-negligible nuclear risk, for example, describing crises in Eastern Europe during the Cold War (Sagan and Suri 2003; Posen 2014). It can also capture crises where there is a higher nuclear risk, describing conflicts between newer nuclear states (like between Pakistan and India, or involving North Korea) with higher chances of missteps or miscalculations in their nuclear command and control systems.

[6] This can be accommodated by shifting the p_0 and p_1 parameters to only consider regions where the relationship is monotonic or non-monotonic.

Additionally, the model can also describe crises where conventional conflict generates no nuclear risk, as it was in the era before nuclear weapons were developed (formally, $n = 0$). That said, the model cannot describe every crisis during the Cold War, including the Second Taiwan Strait Crisis (where China did not possess a nuclear weapon), and the Cuban Missile Crisis (where nuclear escalation risk was generated outside of conflict). Additionally, the model can also offer insights into potential future crises between nuclear states, like a crises between the US and China over Taiwan.

4 Equilibrium

In the game, D's initial arming selection will shape how D and C behave in the rest of the game, ultimately leading to three different equilibrium paths. First, D could arm to a level that deters C from ever challenging, resulting in D getting the asset outright. Second, D could arm to a level where C and D will fight. Third, D could not arm, resulting in C challenging, D acquiescing, and C getting the asset. I elaborate on these below.

For D to deter C, D must select a conventional force level where two conditions hold: (a) D must be willing to fight when challenged, and (b) C knows that fighting D is sufficiently bad for it. These two conditions function as constraints that must be satisfied for deterrence to hold. When condition (a) is met, D has selected force posture that satisfies their *war participation constraint*, meaning that D has selected a force posture at or beyond the minimum level where D would be willing to fight if challenged. Formally, this is any p greater than or equal to p^D, where[7]

$$p^D = 1 - \frac{\alpha v_D}{c_D + nN_D}.$$

For the deterrence condition (b), to be met, D must have set a sufficient force posture where, should D escalate, C does sufficiently poorly in the ensuing conflict. Essentially, when (b) is met, D selects a force posture that meets C's *war cost constraint*, meaning that D has set a force posture at or beyond the minimum level where C's costs from going to war outweigh C's benefits from challenging. Formally, this is any p greater than or equal to p^C,[8] which satisfies

$$p^C = \frac{\alpha v_C}{c_C + nN_C}.$$

Together, for deterrence, D will select the smallest force posture where both D's war partici-

[7]Formally, p^D solves $0 = \frac{n}{h(p^D)} * (-N_D) + \frac{\alpha}{h(p^D)p^D(1-p^D)}\left(p^D v_D\right) - \frac{c_D}{h(p^D)}$.
[8]Formally, p^C solves $0 = -\frac{n}{h(p^C)}N_C + \frac{\alpha}{h(p^C)p^C(1-p^C)}\left((1-p^C)v_C\right) - \frac{c}{h(p^C)}$.

pation constraint and C's war cost constraint are met—formally, if D sets $p = max\left\{p^C, p^D\right\}$, C will be deterred. Importantly, only one constraint will bind. When C's war constraint binds ($p^D < p^C$), D can arm to a level where D is willing to fight, but must arm further to make war sufficiently costly for C and actually deter C. In contrast, when D's war participation constraint binds ($p^D > p^C$), so long that D has armed to a level where D is willing to fight, C will be deterred. Depending on which constraint binds, the model produces distinct comparative statics.

Alternatively, as is common in deterrence models, sometimes D and C will fight.[9] Suppose D has armed to a level where D's war participation constraint is met but C's war cost constraint is not met. Formally, whenever $p^D < p^C$, D may most prefer selecting some arming level that results in fighting.[10] D prefers to fight when D values the asset but is not willing to or cannot arm up to the level that will deter C outright (i.e., D prefers to arm past $p = p^D$, but prefers not to arm to level $p = p^C$ or cannot when $p^C > p_1$). When D does best fighting, D optimizes by setting $p = \hat{p}$, where

$$\hat{p} \in argmax_{p \in [max\{p^D, p_0\}, min\{p^C, p_1\}]} \left\{ \frac{n}{h(p)} * (-N_D) + \frac{\alpha}{h(p)p(1-p)} (pv_D) - \frac{c}{h(p)} - K(p) \right\}.$$

I define D's utility from setting $p = \hat{p}$ as $U_D(\hat{p})$. There are two technical issues to note. First, the set $\hat{p}$ may not be singleton, in which case I abuse notation and let $\hat{p}$ define the smallest element of that set. Second, whenever $\hat{p} = p^C$, then D prefers arming to level $p = p^C$, which in equilibrium (characterized below) will result in C being deterred.

Finally, D may opt not to arm. If D does not value the asset much or faces high costs to arming, D may select the smallest force posture and acquiesce when challenged.[11]

I make two simplifying assumptions.

Complete Information Game Assumptions: *D must arm in order to be willing to fight, and there is a feasible level of arming where D is willing to fight. Formally,* $p^D > p_0$ *and* $p^D \leq p_1$.

These assumptions rule out fairly uninteresting equilibrium cases. If the first condition does not hold and $p^D \leq p_0$, then D's war participation constraint is always met and, in some cases, can deter C without any arming. By making this assumption, this model only analyzes scenarios

[9] I discuss this more in Section 7.2 below.

[10] Formally, the set of feasible p values are $p \in \left[max\left\{p^D, p_0\right\}, min\left\{p^C, p_1\right\}\right)$. Whenever $p^D \geq p^C$ holds, fighting is not possible in equilibrium: if $p \geq p^D$, then C will be deterred, and if $p < p^D$, then D's war participation constraint is not met.

[11] For this to occur, it must be that $p_0 < p^D$, which is assumed below.

where D must intentionally place troops for deterrence. Second, if $p^D > p_1$, then D's war participation constraint is never met, making deterrence impossible.

With these assumptions in place, I can describe the equilibrium behavior (Proposition 1). To summarize the intuition around the three cases in the Proposition, D's arming decision depends on what arming options are available, and what gives D the greatest utility. For example, suppose C's war cost constraint cannot be met ($p^C > p_1$), which means D cannot ever keep C from challenging and therefore cannot deter C. Whenever $p^C > p_1$, D will choose between (a) not arming and acquiescing (setting $p = p_0$) and (b) going to war (setting $p = \hat{p}$), depending on which gives D the greater utility. Alternatively, suppose D's war participation constraint binds, meaning D being willing to fight is enough to deter C ($p^C \leq p^D$). Here, D chooses between deterring C and acquiescing. The equilibrium is as follows.

Proposition 1*: There exists an essentially unique*[12] *subgame perfect equilibrium taking the following form. Working backwards, if challenged, D will fight whenever* $p \geq p^D$ *and will acquiesce otherwise. Before D fights or acquiesces, C will challenge unless both* $p \geq p^C$ *and* $p \geq p^D$*, and will not challenge otherwise. And before C challenges or not, D will select the following arming levels (letting* p^* *denote equilibrium arming levels).*

- ***Case 1:*** *When* $p^D < p^C \leq p_1$*,*
  - *If* $V_D - K(p^C) \geq 0$ *and* $V_D - K(p^C) \geq U_D(\hat{p})$*, then D selects* $p^* = p^C$ *(D deters C).*
  - *If* $0 > V_D - K(p^C)$ *and* $0 > U_D(\hat{p})$*, then D selects* $p^* = p_0$ *(D acquiesces).*
  - *Otherwise, D selects* $p^* = \hat{p}$ *(D and C fight).*
- ***Case 2 (deterrence is impossible):*** *When* $p^D < p^C$ *and* $p^C > p_1$*,*
  - *If* $U_D(\hat{p}) \geq 0$*, then D selects* $p^* = \hat{p}$ *(D and C fight).*
  - *Otherwise, D selects* $p^* = p_0$ *(D acquiesces).*
- ***Case 3 (fighting is impossible):*** *When* $p^C \leq p^D$*,*
  - *If* $V_D - K(p^D) \geq 0$*, then D selects* $p^* = p^D$ *(D deters C).*
  - *Otherwise, D selects* $p^* = p_0$ *(D acquiesces).*

[12] Two other types of equilibria could also exist. First, mixed-strategy equilibria can exist when players are indifferent over their actions. For example, if $U_D(\hat{p}) < 0 = V_D - K(p^C)$, D could mix over $p = p_0$ and $p = p^C$. Second, the optimal selected p conditional on D wanting to fight C could take on multiple values that D could mix over. Ultimately, I assume assuming that neither D nor C is mixing over actions that they are indifferent over.

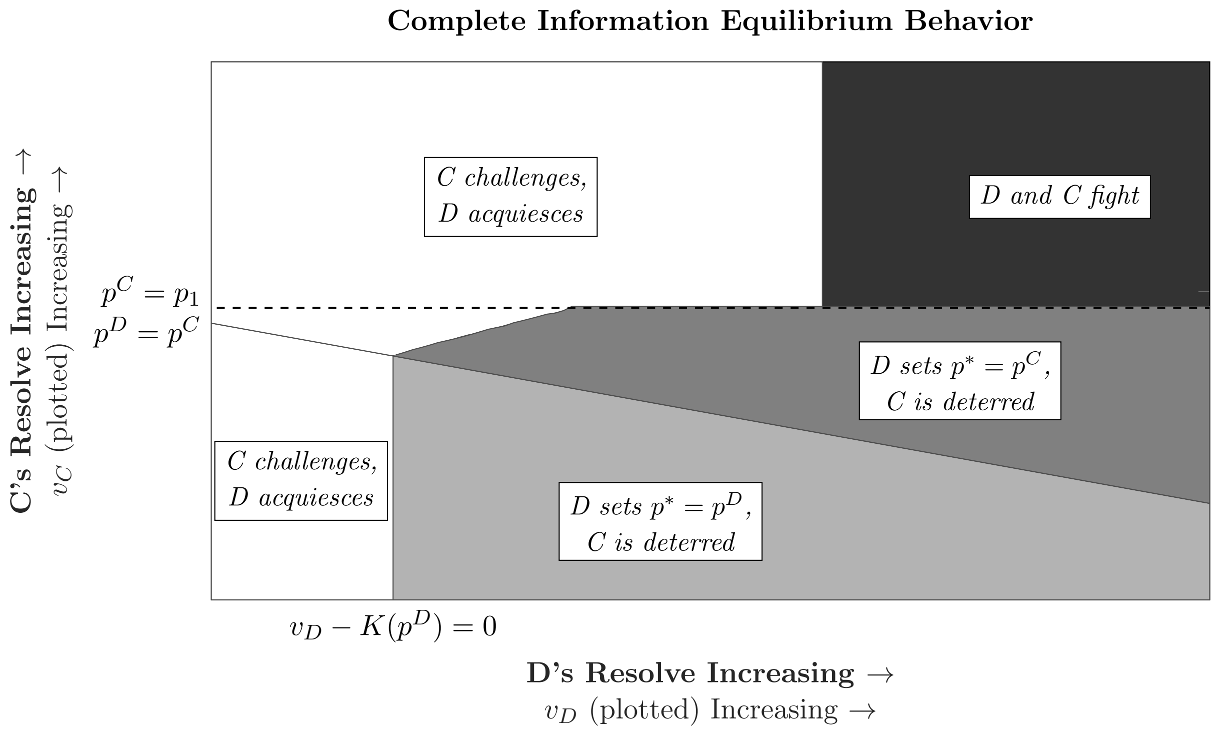

Figure 2: Equilibrium spaces in the complete-information deterrence game. For all white spaces, C will challenge and D will acquiesce. For all light-gray spaces, C will be deterred. And for all dark-gray spaces, C and D will fight.

Proofs are given in the appendix.

Figure 2 displays the logic of Proposition 1 for one set of parameters. v_D values are increasing on the x-axis, and v_C values are increasing on the y-axis. Intuitively, as v_D and v_C increase, actors value the asset more and become more willing to fight.

First, consider the diagonal line labeled on the y-axis as $p^D = p^C$. For all values below this line, $p^C < p^D$, meaning fighting is not possible, but deterring C is possible (Case 3). For the lowest values of v_D (bottom-left), D does not value the asset enough to arm to deter. Here D will set $p^* = p_0$, C will challenge, and D will acquiesce. Then, moving to the right along the x-axis, when v_D increases enough, D prefers arming to the level that will deter C from challenging to not arming and letting C have the asset; for all v_D values including and to the right of the $v_D - K(p_D) = 0$ cut-point (which are values where $v_D - K(p_D) \geq 0$), D will arm to level $p^* = p^D$ and deter C.

Next, consider the v_C and v_D values that fall above the $p^D = p^C$ line, where $p^D < p^C$, but below the $p^C = p_1$ dotted line, where $p^C < p_1$ (Case 1). Here D can arm with the intent of acquiescing, deterring, or fighting. When D does not value the asset much (low v_D), D will set $p^* = p_0$ and acquiesce. And when D values the asset more, D will arm to level $p^* = p^C$, which will deter C. In this region, for the selected parameters, D never prefers going to war.

Finally, consider the region above the dotted line labeled $p^C = p_1$, which is where $p_1 < p_C$. For this region, C values the asset so highly that no feasible arming level will fully convince C not to fight—deterrence is not possible (Case 2). Thus D will either not arm and acquiesce (when v_D is lower), or arm in preparation for a fight (when v_D is higher).

Figure 2 depicts one equilibrium for a range of parameters. Under different parameters, these regions will look different, or different cases may (or may not) be represented.

In the next section, I discuss the general features of the equilibrium.

5 Results

5.1 Introducing Nuclear Risk can Result in More or Less Conventional Arming for Deterrence

Introducing or increasing the unintended risk of nuclear escalation makes both C and D do worse in a conventional conflict. For this reason, added nuclear instability can cut both ways on D's initial arming decision.

Remark 1: *Nuclear weapons and nuclear risk are imperfect substitutes for conventional forces. Formally, increasing nuclear instability (n) can increase or decrease the equilibrium force posture (p^*).*

Increasing the level of nuclear instability could result in D selecting greater or lower levels of conventional arming. This duality is clearest when D is trying to deter C. For deterrence, both D's war participation constraint and C's war cost constraint must be met (formally, D selects $p = max\{p^C, p^D\}$). Consider when D's war participation constraint binds ($p^D > p^C$). As nuclear instability increases, in order for D to continue be willing to fight, D must attain a better expected outcome in the conventional conflict to compensate for the greater nuclear risk. D can achieve this better outcome by selecting a greater initial force posture, or greater p.[13] Alternatively, suppose C's war cost constraint binds, and D must arm to a level designed to make challenging sufficiently bad for C ($p^D < p^C$). As the risk of nuclear escalation increases, C does worse in the conventional conflict and wants to challenge less, meaning C will be deterred by a more limited force posture, or lower p.[14] Together, depending on whether D's war participation constraint or C's war cost constraint binds, increasing nuclear instability could result in D

[13]Mathematically, p^D is increasing in n.
[14]Mathematically, p^C is decreasing in n.

selecting greater or lower equilibrium force postures. Note that in the Appendix, I include a more detailed, technical discussion on when p^* is increasing or decreasing in n based on model primitives and equilibrium behavior.

Remark 1 captures the difficulty in attempting to use nuclear risk as a substitute for conventional capabilities in deterrence, which can challenge some existing orthodoxy on nuclear weapons. Waltz (1981) describes several reasons states may want nuclear weapons: "Some countries may find nuclear weapons a cheaper and safer alternative to running economically ruinous and militarily dangerous conventional arms races. Nuclear weapons may promise increased security and independence at an affordable price." Within the scope of this paper—where a strategic nuclear exchange is a background risk within a conventional war—only sometimes can nuclear weapons serve as an alternate to conventional arming.[15] Sometimes, increasing nuclear risk or increasing a nuclear arsenal (which indirectly increases risks) makes D less willing to fight over issues, which means that unless D invests in a *more* robust conventional force posture, D will not be willing to fight when challenged.[16]

Remark 1 also has policy implications. Consider the 2010 Nuclear Posture Review, which states that "fundamental changes in the international security environment in recent years—including the growth of unrivaled US conventional military capabilities [and] major improvements in missile defenses— enable us to fulfill[. . .] objectives at significantly lower nuclear force levels and with reduced reliance on nuclear weapons [. . .] without jeopardizing our traditional deterrence and reassurance goals" (Leah and Lowther 2017). On the one hand, the model partially supports this assessment, as a robust conventional force posture can sometimes still deter in settings where a nuclear force posture (and thus nuclear instability level) is lowered. On the other hand, if the challenger's war participation constraint binds and nuclear instability is key in deterring rivals, then reducing reliance on nuclear weapons could require an expansion in conventional forces or existing deterrent threat will be jeopardized. It remains an open question how the scope of challenges would change when nuclear instability is lowered.

5.2 Welfare Outside of Conflict

By shifting equilibrium force posture levels, increasing nuclear instability can also affect overall welfare.

Remark 2: *Outside of war, increasing nuclear instability (increasing n) can decrease or increase overall welfare.*

[15] In an alternative setting, where one state faces an existential threat and nuclear weapons are used as a last resort, the Waltz (1981) comments seem fully correct.

[16] Admittedly, Waltz (1981) may be also be discussing tactical nuclear weapons. I discuss this below.

As one example of how Remark 2 holds, consider what increasing nuclear instability means for welfare when D optimally deters C. As discussed in Remark 1, as nuclear instability increases, D selects greater or lower force postures to deter C; in turn, this generates either greater costs or lower costs (respectively) for D to achieve the same deterrence outcome. Together, increasing nuclear instability can constitute a Pareto improvement, when D can deter C by positioning fewer forces—or can be Pareto inefficient, when D must place more forces to deter C.

This point has not been studied. In previous scholarship, nuclear optimists point to the decrease in great power conflict as a virtue of the nuclear era (De Mesquita and Riker 1982). In contrast, nuclear pessimists typically note that, even if nuclear weapons reduce the likelihood of war, whenever war is not ruled out altogether, it becomes more costly as it bears the risk of a catastrophic nuclear exchange (Sagan 1985, 1994). This trade-off—nuclear weapons mean fewer wars but introduce existential risks—has dominated the academic discourse (Kydd 2019). However, this paper presents a new trade-off. In the nuclear era, establishing deterrence may necessitate more robust force postures, ultimately generating greater systemic costs.

5.3 Evidence of a "Nuclear Peace"

Consistent with the arguments of nuclear optimists and some empirical evidence (Asal and Beardsley 2007), this model suggests that introducing nuclear instability can lead to a more peaceful state of the world.

Remark 3: *Increasing nuclear instability results in fewer instances of war. Formally, I define nuclear instability parameters $n', n'' \in \mathbb{R}_+$, with $n' < n''$. If n' shifts to n'', then the set of parameters where war occurs shrinks, and the likelihood of war weakly decreases.*

Moving from a low to a high level of nuclear instability will shrink the parameter set under which a conventional war will occur. To interpret this result, Remark 3 implies that if we compared how history played out from 1950 to the present ($n > 0$) to a counterfactual history without the development of nuclear weapons (1950 to the present, but with $n = 0$), we would observe more conventional conflicts in the counterfactual history. Put simply, this model confirms that added nuclear instability lowers the likelihood of conventional war.

Two forces drive the nuclear peace. First, as nuclear instability increases, a conventional war becomes worse for the defender because the risk of nuclear escalation grows. Second, as nuclear instability increases, the set of possible force posture levels that could result in war—in other words, arming levels where C would be willing to challenge and D would be willing to escalate if challenged—is shrinking, potentially making deterrence cheaper. Together, D will do worse from fighting a conventional war, and therefore will go to war less.[17]

Figure 3 shows this visually. It includes three plots, each with fixed parameters (other than n, which increases from top to bottom). In the top plot, $n = 0$ (there is no risk of a nuclear exchange), and there is a large range of values where the game ends in war. In the middle plot $n = 0.03$, and in the bottom plot $n = 0.06$. As n increases, the dark-gray region where war occurs shrinks, and the regions where D acquiesces or D deters C grow.

5.4 Nuclear Instability, Nuclear Costs, and Arming Incentives

In the nuclear era, the defender has a new incentive: to avoid prolonged conflicts which carry a greater risk of a nuclear exchange. As a result, when the defender arms to fight, they arm with the intent of fighting more decisive conflicts. What is different and new here is that the defender may select a more aggressive or a less aggressive deployment of force.

Remark 4: *Under select conditions, as nuclear instability increases (n increases) or D's costs of a nuclear exchange increase (N_D increases), D will select a more or less aggressive force posture, generally making conflicts shorter and more decisive. Formally, consider nuclear cost parameters N'_D and N''_D, and nuclear instability parameters n' and n'', where $N'_D < N''_D$ and $n' < n''$. Suppose D optimally goes to war under both sets of parameters (i.e., $p^* = \hat{p}$).*

(a) If $p^*(N'_D) \leq \frac{1}{2}$, $p^*(N''_D) \leq \frac{1}{2}$ and $p^C > \frac{1}{2}$, then $p^*(N'_D) \geq p^*(N''_D)$.[18] And if $p^*(N'_D) \geq \frac{1}{2}$, $p^*(N''_D) \geq \frac{1}{2}$, and $p^D(N''_D) < \frac{1}{2}$, then $p^*(N'_D) \leq p^*(N''_D)$.

(b) If $p^*(n')$ and $p^*(n'')$ are small enough, and $p^C(n'') > \frac{1}{2}$,[19] then $p^*(n') \geq p^*(n'')$. And if $p^*(n')$ and $p^*(n'')$ are large enough, $p^D(n'') < \frac{1}{2}$, and $p^C(n'') \geq p_1$, then $p^*(n') \geq p^*(n'')$.

Remark 4 suggests that as nuclear instability or the costs of a nuclear exchange increases, D will arm so that conflicts will be shorter and more decisive. For example, suppose for a given n and N_D that D initially optimally armed to a level below $p = \frac{1}{2}$ with the intent of fighting; if n or N_D increases, then D will generally lower their optimal arming level. And, D initially armed to a level above $p = \frac{1}{2}$ with the intent of fighting, then raising n or N_D would increase D's optimal arming level. This latter finding (increasing n leading to higher p) is new.

Figure 4 visualizes Remark 4. The left graph illustrates the equilibrium arming level (y-axis) for a range of v_D values (x-axis) under a set of parameters where low-resolve D's always fight. The

[17] Formally, D's payoff from fighting a conventional war is the maximum of a constrained optimization problem: as nuclear instability increases, D's objective function produces worse options, and the set over which D optimizes shrinks.

[18] As defined earlier, $\hat{p}$ may represent the minimum value of a set. Here, when I say $p^*(N'_D) \leq p^*(N''_D)$, I abuse notation and assume that every element of both $p^*(N'_D)$ and $p^*(N''_D)$ is less than or equal to $\frac{1}{2}$.

[19] We will clarify "small enough" and "large enough" in the appendix.

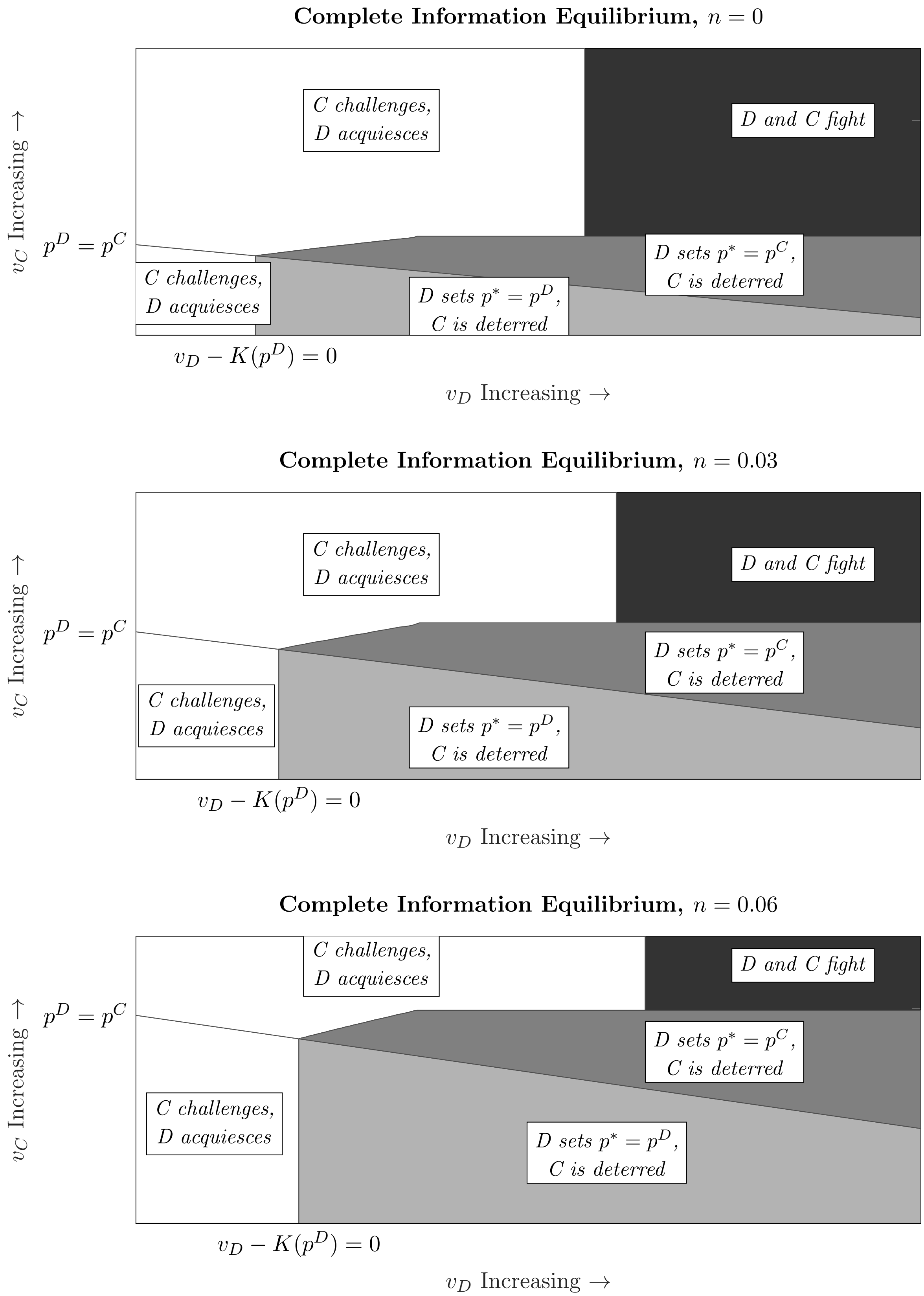

Figure 3: Equilibrium spaces in the complete-information deterrence game. Instability parameter n increases from top to bottom.

different dot styles capture changes in D's nuclear cost, N_D. The open dots plot the equilibrium arming levels when the costs of a nuclear exchange are low ($N_D = 10$), and the closed dots when those costs are high ($N_D = 30$). The right graph considers changes in nuclear instability, n, where open dots are for $n = 0$ and closed dots are for $n = 0.07$.

Consider the left graph of Figure 4. As N_D increases (moving from open to closed dots), equilibrium arming levels below the initial arming level of $p^* = 0.5$ decrease, and equilibrium arming levels above the initial arming level of $p^* = 0.5$ increase. For any $p < 0.5$, if D adds force posture, then D will be moving toward force parity; for any $p > 0.5$, if D adds force posture then D will be moving away from force parity. Remark 4 implies that if D was arming to some $p^* < 0.5$ ($p^* > 0.5$) under some cost of nuclear war N_D, and if the costs of nuclear war increase, then D would move to a lower (higher) arming level to make the conflict more decisive. Next, consider the right-hand graph of Figure 4. As n increases (moving from open to closed dots), equilibrium arming levels shift in a slightly different manner: as nuclear instability increases, D generally arms more decisively, but does not do so for a range of values around $p^* = 0.5$. Why? In short, this is a more complicated relationship, as n factors into a wider range of conflict payoff terms (like the conventional conflict costs). In the appendix I offer a more precise analysis and show that generally D arms for more decisive conflicts.

This remark relates to the stability–instability paradox. The paradox suggests that "stability" between adversaries at the nuclear level (i.e. adversaries each possessing a capable nuclear arsenal but where there is little risk of escalation) can breed "instability" (i.e. conflict) at lower levels (Snyder 1965; Jervis 1984). Empirically, there is some evidence that while the great powers avoided direct, large-scale conventional conflict, they did engage frequently at lower levels of conflict (Rauchhaus 2009; Early and Asal 2018).[20] Consistent with the paradox, Powell (2015) finds that strategic states respond to greater nuclear instability with more restrained levels of force in conflicts (when they occur), and that this offers an explanation for India's restraint during the Kargil War.

While under some parameters these results echo Powell, at other times I find that defenders commit more force to a conflict when faced with greater nuclear instability and greater nuclear costs. Why? This is where the non-monotonic relationship between arming and nuclear risk matters. The defender is incentivized to avoid prolonged conflicts, because they bear a greater risk of a nuclear exchange. And here (unlike in Powell), the defender can avoid prolonged conflicts by reducing military parity through greater or lower levels of arming. Whereas Powell finds that conventional conflicts with nuclear risk should always exhibit lower levels of force, I find that these conflicts will generally be more decisive and less prolonged, which may involves

[20]Alternate work suggests these effects may not be present, see Lee et al. (2023).

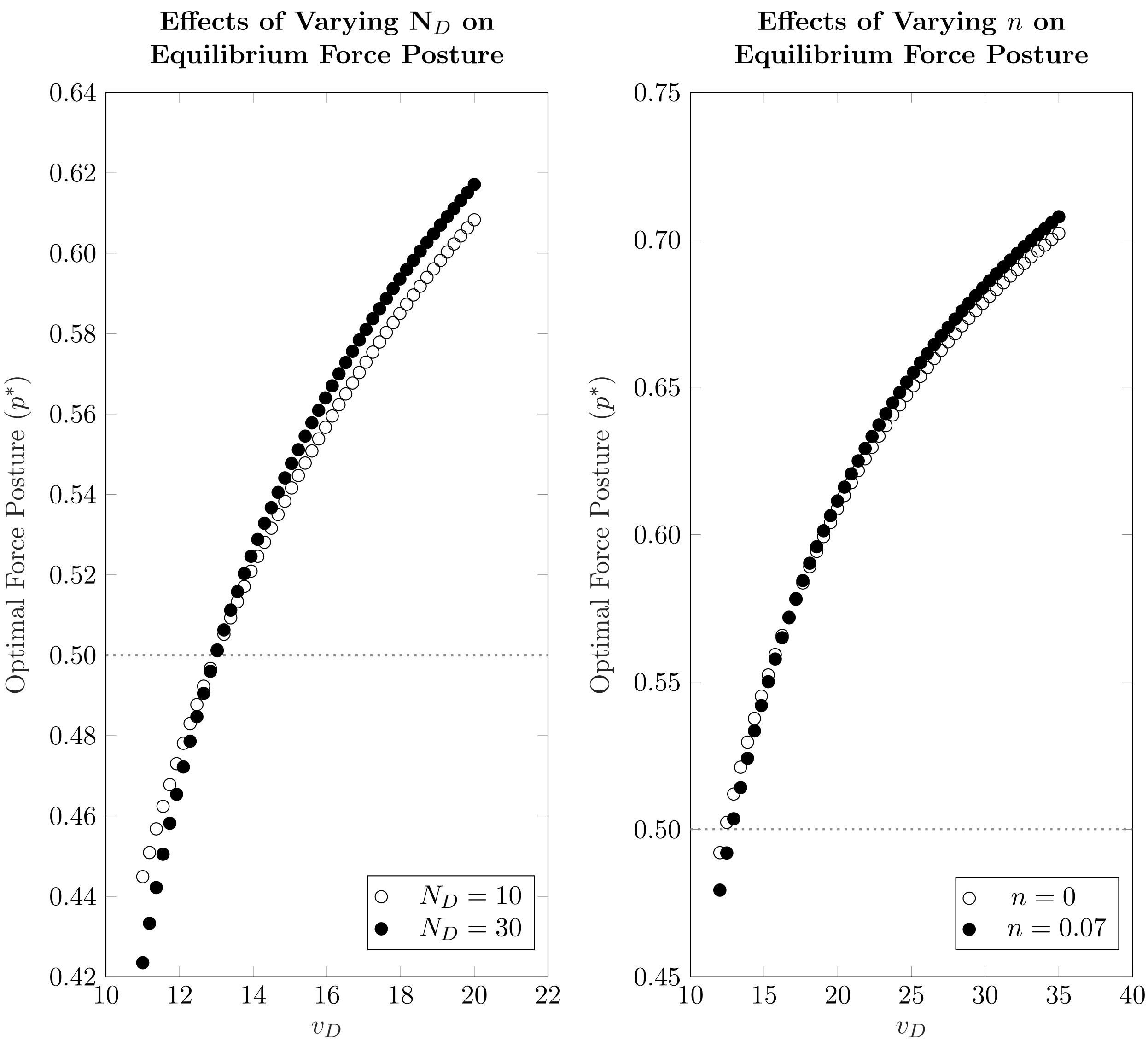

Figure 4: Optimal arming levels for D. *Left*: increasing D's costs from a nuclear exchange, N_D, from 10 to 30 results in D selecting greater or lower levels of arming such that conflict becomes less protracted. *Right*: increasing nuclear instability parameter n from 0 to 0.07 also can result in D arming in such a way as to make the conflicts less protracted, but this result is not as clean around $p = 0.5$.

more aggressive force postures. I discuss the substantive implications in Section 6.2.

5.5 Deterrence Failure and Nuclear Instability

Remark 5: *Increasing nuclear risk can increase or decrease instances of deterrence failure.*

I classify a "deterrence failure" as any equilibrium where C challenges D. As nuclear instability increases, deterrence failures could become more or less common. Two competing effects drive this. First, suppose for a given n that D's war participation constraint binds ($p^D > p^C$). Here, D can deter C by arming to level $p = p^D$. If n increases, then D becomes less willing to fight, which increases D's required arming level p^D, possibly to the point where D is unwilling to undertake the costly arming needed to deter C from challenging. If this occurs and D is no longer willing to deter C from challenging, then the increase in n produces a deterrence failure. Second, suppose for a different set of parameters, C's war cost constraint binds ($p^C > p^D$). In some cases, D may be unwilling to arm to level p^C and deter C under a low level of nuclear instability; however, greater nuclear instability lowers p^C, which can make D willing to arm and prevent a deterrence failure.

These findings pose a useful counterpoint to Mearsheimer (1990), which states that "deterrence is most likely to hold when the costs and risks of going to war are unambiguously stark."[21] Using the definition of deterrence failure here, the model can identify when this conjecture holds and when it does not. A high nuclear risk can, at times, undermine D's deterrent threat and encourage C to challenge.

6 Empirical Implications

Most surprising and new, the theory above suggests that with the introduction of nuclear risk, states may sometimes act more decisively within conflicts (Remark 4) and must sometimes arm more to establish a deterrent threat (Remarks 1 and 5). In this section, I highlight a several real-world cases where actors behave with less restraint than previous theories predicted (Powell 2015).[22]

[21] The model also confirms that deterrence is more likely to hold when the costs of a nuclear war for the challenger (N_C) are high, but more likely to fail when the costs of a nuclear war for the defender (N_D) are high.

[22] Because the theory here also predicts that, in the nuclear era, states may sometimes act with more restraint, existing studies of incidents like the Kargil War confirm the theoretical findings presented here.

6.1 Challenges of the New Look Doctrine

The Remarks offer formalized insight into the frustrations of the Eisenhower administration. Eisenhower's New Look national security policy sought to establish a robust deterrence while minimizing military expenditures by emphasizing air and nuclear power while reducing spending on the army and navy (Gaddis 2005). While the US was successful in some cases in maintaining a successful deterrent threat, Eisenhower left office having only slightly reduced the US defense budget,[23] all the while warning of the corrosive effect this spending had on American politics and society (Eisenhower 1961).

Part of Eisenhower's frustration stemmed from the difficulty of using nuclear threats to deter small transgressions. These difficulties have been discussed in previous scholarship, and by Eisenhower himself (Gaddis 2005; Freedman 1989). But Remarks 1 and 2 highlight an additional challenge. If conventional forces function as Schelling (1966) discussed—where they bid up the risk of a nuclear exchange—then conventional wars take on a new, much worse dimension in the nuclear era. Even if conventional wars carry nuclear risks, it may become more difficult to deter challengers. In the nuclear era, the defender's willingness to fight must account for latent nuclear risk, which may require an over-investment in its convectional force posture relative to what would be needed without that risk. Thus, deterrence may perversely become more expensive.

It is worthwhile mentioning that Remarks 1 and 2 describe effects within specific crises. Unfortunately, the theory cannot independently identify the aggregate effects of introducing nuclear instability on (for example) defense budgets or defensive force postures. Rather, these results suggest that conventional arming and background nuclear risk have a case-dependent relationship.

Additionally, Remark 5 can speak to how successful the New Look was in deterring adversaries. On the one hand, the background threat of nuclear risk seemed to work in the Eisenhower administration's favor in Western Berlin; despite a conventional force deficit, deterrence held because the forces present could effectively bid up the nuclear risk. On the other hand, the administration failed to deter the spread of communism (or communist-allied regimes) in the Middle East, Latin America, and Asia, and failed to prevent the brutal repression of the anti-communist revolution in Hungary. In short, the theory here suggests that while the New Look policy plausibly contributed to some of the deterrence successes that the Eisenhower administration faced, it also potentially contributed to some of the deterrence failures as well.

[23] The Correlates of War Project National Material Capabilities (v. 6.0) states the defense budget was $49.6 billion in 1953 and $47.8 billion in 1961 (Singer 1988). Other sources suggest the military budget increased in this time (Gaddis 2005).

6.2 Nuclear Risk and Force Postures: The Hungarian Revolution and Kashmir (2019)

The remarks also offer some formalized insight into aggressive uses of force in the nuclear era.

In late October 1956, Budapest was in crisis. Following a series of clashes between student protesters and government forces, a group of anti-Soviet revolutionaries ousted or killed a critical mass of Hungarian communist leaders and members of the Hungarian secret police, eventually (on October 27) installing Imre Nagy as prime minister. At first Soviet leadership considered negotiating with Nagy and the new Hungarian government, but after several days they changed course and invaded Hungary. By November 3, Operation Whirlwind was underway; 30,000 Soviet troops invaded Hungary and circled Budapest (Gati 2006). By November 11, Soviet forces had decisively defeated the revolutionaries, deposed the revolutionary government, and resumed control of Hungary.

In the broader Cold War context, the Soviet activities in Hungary were not without international risks. Until that point, the Eisenhower administration had publicly advocated the "rolling back" of Soviet influence in Eastern Europe, even if it required using armed forces (Borhi 1999). In fact, Soviet leadership acknowledged that the crisis in Hungary had international dimensions, because it could spread to other Soviet states (Kramer 1998) and lead to a confrontation with the West (Göncz, Gati and Ash 2002). But these escalation risks did not convince the Soviet Union to apply less force; instead, it acted aggressively and crushed the revolution. Why?

Before analyzing the events, it is worthwhile grounding the case in the model's terms. The Hungarian Revolution presented the US and USSR with a crisis that could have escalated into a general war that would have come with nuclear risk (Holloway and McFarland 2006). I treat the Soviet Union as the model's "defender" (of the pre-revolution status quo in Hungary), and the West as the "challenger," who could have backed the Hungarian Revolutionaries. The Soviet Union achieved the decisive outcome it did by putting forward a strong conventional force posture, as the defender does in the model.And, in response to the Soviet Union's force posture, the United States had the option to challenge and support the revolution or to stay back.

The model presented here can offer insight into the Soviet Union's robust response. The Soviet Union's conventional force posture in Eastern Europe and the significant forces deployed to quell the Hungarian Revolution all but guaranteed that the Soviet Union would do well should the crisis escalate into a conflict with the West—essentially, the Soviets had selected a high p. This meant that the West would be likely deterred from escalating this crisis, but even if it was not deterred, Soviet conventional forces could plausibly end the conflict quickly enough. And nuclear escalation here was a real concern because a conflict in Eastern Europe risked inadvertent escalation, accidents, or accidental overreach. Consider what Remark 4 suggests here: the background nuclear risk may have incentivized the Soviet Union to select a more aggressive conventional force posture than it otherwise would have. Rather than risk a protracted conflict that would have time to escalate, the Soviet Union moved aggressively to end the crisis quickly, at the expense of the Hungarian revolutionaries and public. The benefits of decisive action were not lost on Khrushchev. As we now know, when Khrushchev's son asked his father (on November 4, 1956) why the Americans had not intervened with military force in Hungary, Khrushchev replied that "everything happened so quickly that possibly they simply did not have time to do so" (Holloway and McFarland 2006).

Our model and analysis suggest that nuclear instability can incentivize both less aggressive military maneuvers, as seen in the Kargil War—and more aggressive military maneuvers, as seen in the Soviet response to the Hungarian Revolution. Of course, in the latter case, there are many potential reasons why a state may want to repress an uprising quickly. But, the Hungarian Revolution is not a the only time that a nuclear-armed state, while maneuvering a crisis with another nuclear-armed state, acted decisively.

For the past several decades, India and Pakistan have periodically clashed over disputed territory in the Kashmir region, including during the Kargil War (1999). In 2019, the government of India abrogated Article 370 of the Indian constitution and passed the Jammu and Kashmir Reorganization Bill, which together dramatically altered the status of the Kashmir territory currently administered by India (Lalwani and Gayner 2020; Bose 2021). Whereas before Jammu and Kashmir possessed a special status as a fairly autonomous Indian state, Delhi's actions eliminated this status, liquidated state's existing institutions and laws, and placed Jammu and Kashmir under the Union government's overarching control. While these abrupt political changes to the contested (and recently fought-over) region heightened tensions between India and Pakistan, in preparation of these political changes, Delhi sent between 40,000 and 45,000 additional soldiers and police forces to Jammu and Kashmir,[24] implemented a lockdown of mobile and internet communications, and rolled out extensive and protracted curfews. This repression made a direct Pakistani military response essentially impossible and greatly curtailed the possibility of third-party backed insurgent activity that could have escalated into a general war between the two countries. In short, India acted decisively, making sure any feasibly Pakistan military response could be dealt with quickly.

While this case comes with many caveats—for example, we lack an insider understanding of Indian decision making—clearly the risks of a confrontation with a nuclear Pakistan did little

[24]This expansion brought the number of Indian troops in the region to 100,000 (Bose 2021).

to moderate India's behavior, in stark contrast to how Indian behaved in the Kargil War (in Kashmir) in 1999. Rather, Remark 4 suggests that the nuclear escalation risk may have incentivised India to act more decisively to insure that any conflict would be quickly resolved.

7 Additional Results and Extensions

I consider several extensions to the model and analysis.

7.1 Making n endogenous.

In some circumstances, the defender may be able to manipulate the level of nuclear risk in the system. A modified version of the game, discussed in the Appendix, explores this prospect. The key change is that as the defender selects their arming level, the defender can also costlessly select some n_D, where n_D determines the level of nuclear instability. For this across-game-form analysis to be informative, I assume that D selects n_D from a compact subset of $\mathbb{R}^1$ that contains n, where n is the nuclear instability parameter from the non-modified game form.

In the equilibrium, sometimes D will select (weakly) greater levels of nuclear instability (i.e. $n_D > n$), and other times D will select (weakly) lower levels of nuclear instability (i.e. $n_D < n$). Why? If C's war cost constraint binds, then by selecting some $n_D > n$, D can deter C at a lower conventional force posture and at lower cost. On the other hand, if D's war participation constraint binds, then by selecting some $n_D < n$, D becomes more willing to fight when challenged, which allows D to establish deterrence at a lower force posture. Together, granting D the option to manipulate the nuclear instability will weakly increase the parameter range where D can deter C.

7.2 Bargaining

The model in the main text was a deterrence model, much like Carter (2010), Gurantz and Hirsch (2017), Baliga, De Mesquita and Wolitzky (2020), the paper this model is closest to (Powell (2015)), and many others. However, some readers may have concerns about the absence of bargaining. Ultimately, if the crisis bargaining setting also has some kind of commitment problem (for example, arising from a power shift or an asset that shapes the future distribution of power), the deterrence setting resembles the crisis-bargaining setting. In the Appendix, I modify the model to (a) allow for endogenous bargaining and (b) have a commitment problem stemming from a power shift. In doing so, I find the above Remarks largely still hold.[25]

[25] Remark 3 is somewhat changed, as discussed in the Appendix.

While the crisis bargaining model with commitment problems presents new scope conditions under which fighting is possible, the results are largely the same. That said, while I examine one version of this model with bargaining, future research should consider more versions of this.

7.3 Caveats to the Nuclear Peace: Effects beyond Nuclear Instability

The true effect of the nuclear revolution on conventional conflict occurrence is potentially more complex than what we have considered so far. This model finds that increasing the nuclear instability parameter n always results in less conventional conflict (Remark 3). A natural interpretation of the nuclear revolution is that the world changed from $n = 0$ to $n > 0$ and, as a result, there should be less conventional conflict between nuclear forces—a kind of nuclear peace.

However, the nuclear revolution also shaped "conventional" capabilities. Several states have nuclear-powered submarines and aircraft carriers. Additionally, it is possible that one day tactical nuclear weapons will be deployed on the battlefield as part of a "conventional" conflict. Because technologies like nuclear submarines are more efficient and capable than their non-fission-powered counterparts, they could lower the costs of conventional war (i.e., reducing c_D and c_C). And, in the model, lowering c_D and c_C have the opposite effect of increasing n: for a given n, lowering the costs of conventional war expands the parameter set under which conventional conflict occurs. Thus, the nuclear peace result could be undermined.

If the nuclear revolution both increased nuclear instability and lowered the costs of conventional war, then understanding the true effect of the nuclear revolution on conflict requires disentangling complex competing effects. Without additional structure, it is not possible to know whether the nuclear peace result will be undermined. Still, given the empirical for the nuclear peace hypothesis (Asal and Beardsley 2007), there is some evidence that the nuclear revolution's effects on conventional war costs do not overshadow the changes in nuclear risk.

8 Extension: Incomplete Information Game

8.1 Model and Equilibrium Intuition

I also analyze a version of the game with incomplete information. Its form is nearly identical to the one described earlier, only here, before D selects its conventional force level, nature designates D's resolve (i.e., how much D cares about the issue) as low or high. Formally, nature sets $v_D \in \{\underline{v}_D, \bar{v}_D\}$, with $0 < \underline{v}_D < \bar{v}_D$. I let $\pi \in (0, 1)$ denote the probability that D is type $\bar{v}_D$, and $1 - \pi$ the probability D is type $\underline{v}_D$. D knows D's type, but C does not. In this game, I limit

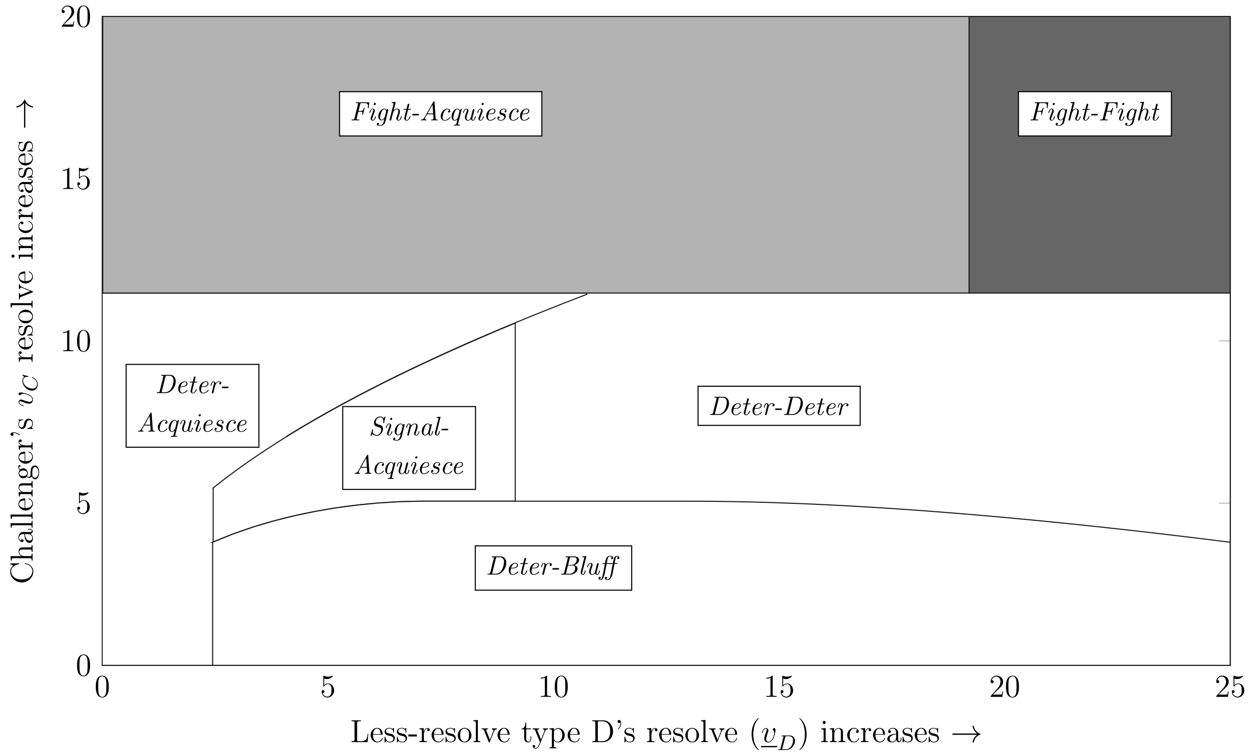

Figure 5: Equilibrium spaces in the incomplete-information game. The x-axis varies $\underline{v}_D$, which is the less-resolve type's valuation of the asset, and the y-axis varies v_C, which is the challenger's valuation of the asset. The darkness of shading represents the likelihood of war. In the white equilibrium spaces, war never occurs. In the light-gray "War-Acquiesce" equilibrium space, war occurs when D is type $\bar{v}_D$. In the dark-gray "War-War" equilibrium space, war always occurs.

analysis to an essentially unique perfect Bayesian Nash equilibrium that satisfies the intuitive criterion (Cho and Kreps 1987). The essentially unique equilibrium of focus is the simplest version of the equilibrium satisfying the intuitive criterion. A full discussion of this equilibrium and the model results are given in the appendix; here I summarize the key points.

In the incomplete information game, there is a new strategic tension: because C is uncertain of D's resolve, sometimes C is uncertain whether D is willing to fight. This in turn can shape D's force posture decisions in new ways, leading to bluffing or signalling (discussed below). But the incomplete information assumption does not change the game everywhere, and much of the behavior is similar to the complete information game (i.e., sometimes different types of D will acquiesce, deter, or fight).

I depict the equilibrium spaces in Figure 5. Here $\underline{v}_D$ varies on the x-axis, and v_C on the y-axis, while other parameters are fixed. The text boxes describe how type $\bar{v}_D$ behaves, then how type $\underline{v}_D$ behaves in each parameter space. A range of equilibrium behavior can be supported. For high values of $\underline{v}_D$ and v_C, both types of D will always go to war. When $\underline{v}_D$ and v_C are lower, sometimes low-resolve defenders will drop out and acquiesce, while high-resolve defenders deter C. Other times, low-resolve defenders will mimic a high-resolve defender's force posture to convince C to not challenge, despite their being unwilling to fight at that force posture (i.e., they bluff). Other times, high-resolve defenders will select a high-enough force posture to get low-resolve defenders to stop mimicking them, thereby demonstrating that they are resolved types (i.e., they signal).

8.2 Results

Adding incomplete information to the complete information model is a natural modification: actors plausibly may not know how much their opponent cares about the issue at stake (Fearon 1995; Gartzke 1999). But, this model modification does not change any of the earlier remarks.

Remark 6*: Remarks 1–5 hold in the incomplete information model.*

Remark 6 is a useful robustness check. Actors play different kinds of equilibrium strategies in the different versions of the model (complete versus incomplete information). Despite this, Remark 6 implies that Remarks 1–5 can also apply to settings where the degree of resolve is unknown, thus expanding the real-world applicability of these results.

The incomplete information model can also generate new results. The model with private resolve here works differently from the model with private resolve in Powell (2015). Here it is possible for the defender to signal its private resolve without ever having to go to war.

Remark 7: *Peaceful signaling of resolve is possible.*

High-resolve defenders signal their resolve by arming beyond the level needed to make themselves willing to fight. Essentially, they must arm to a level low-resolve defenders would not be willing to match (due to the cost), and where high-resolve defenders would fight if challenged. This is $\bar{p}$.[26] As a result, in equilibrium, only high-resolve D's arm to level $\bar{p}$; C knows upon seeing $p = \bar{p}$ that D is resolved and would fight if challenged, and C will never challenge.[27] Within the parameter set where D signals, arming as a costly signal of resolve always works in that there is always peace.

In Powell (2015), signaling functions differently. There, manipulating nuclear risk—which is how the defender signals its resolve—is costless unless a conventional war breaks out. And, following the standard signaling logic, unless the signal is costly, low-resolve types are incentivized to mimic high-resolve types, and this undermines the informative value of the signal. As a result,

[26]Formally, this value is characterized by $\underline{v}_D - K(\bar{p}) = 0$, with $\bar{p} \geq p^D(\bar{v}_D)$.
[27]Naturally, this supposes that $\bar{p} \geq p^C$.

in Powell, the defender can only signal its resolve by sometimes actually going to war, because the signal only generates costs through war.Arming as a costly signal does effectively separate low-resolve types from high-resolve types, but the equilibrium is not always peaceful.

This distinction has real-world implications. My model suggests that resolved defenders can deter challengers and prevent conflict through the signal of a robust conventional force posture. In contrast, Powell (2015) finds that manipulating nuclear risk cannot function as a fully effective deterrent against challengers, so conflict must sometimes break out. There are two ways to interpret these results. First, I am presenting a more optimistic perspective. For Powell, war is an inevitable part of the signaling of resolve, whereas I find it is possible to signal resolve and deter an opponent without ever having to resort to conflict. Second, from a practical perspective, if a defender wants to signal resolve and avoid conflict, manipulating nuclear risk (as in Powell) can lead to much worse outcomes than manipulating force posture.

9 Conclusion

Every day, every human on earth lives with the background risk of a catastrophic nuclear exchange (Sagan 1985). But there may be some benefit to this: in some cases, adding latent nuclear instability reduces the likelihood of a conventional war. My model suggests that the observed "long peace" could be a "nuclear peace," where the nuclear great powers are less willing to engage in large conventional wars and more willing to engage in small, regional contests with small risk of nuclear escalation.[28]

Of course, as this paper has demonstrated, this latent nuclear risk does not come without costs. While much attention has been paid to the underlying risks that nuclear weapons hold (Sagan and Waltz 1995; Kydd 2019), this paper demonstrates that nuclear weapons can reduce welfare through other channels as well. In a nuclear world, deterrence may become more difficult and costly: states might find themselves investing more in their conventional force posture to make their deterrent threat credible. The formalized logic here may explain why Eisenhower struggled to reduce defense spending in the nuclear era, and why spending on conventional arms remained high during the Cold War. While generalizing these results to systemic trends would require caution, the key take-away is that the nuclear peace may be more inefficient than otherwise expected. More research on this is needed.

This paper also offers a new perspective on how conflict should play out during the nuclear era: the nuclear era may not be solely a period of restraint and limited wars but also a period of aggression, where actors sometimes put forward more robust conventional force postures

[28] With caveats, as discussed above.

with the intent of shortening conflict duration. This formal result is new, and comes about by bridging two previously unrelated strands of research: research on conventional capabilities and conflict duration, and research on how nuclear risk is generated. This new model suggests both the restraint used during the Kargil War and the robust force deployed during the Hungarian Revolution and in Kashmir (2019) can be explained by the nuclear revolution.

This paper can also offer some insight into recent research on nuclear proliferation. This research commonly assumes developing nuclear weapons or extending deterrence comes with immediate benefits for the state developing nuclear weapons or gaining the guarantee of nuclear deterrence (Bas and Coe 2012, 2016; Spaniel 2019*a*; Fuhrmann and Sechser 2014). This may be the case: when state is in a dispute over matter of existential importance, having a nuclear weapon can be a significant bargaining tool. However, in other matters, the state that is developing nuclear weapons may find itself investing more in conventional capabilities to maintain their deterrent threat. In theory, this can also apply to extended nuclear deterrence: allies under the nuclear umbrella may need to arm more to maintain their willingness to fight, lest they find themselves unable to deter opponents over important-but-not-existentially-important political matters.

Future research should continue examining nuclear deterrence theory. Moving forward, war should not be treated as a game-ending move with a specific functional form. One way to move forward would be to treat war as a continuous-time process, where states can "drop out" at any time. Indeed, the setup here would lend itself to this, with n and $\frac{\alpha}{p(1-p)}$ being used as hazard rates for the conflict ending via a nuclear exchange or a conventional victory, respectively. Alternatively, the functional forms for conflict could be generalized.

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