Conflicts that Leave Something to Chance: Conventional Conflict, Nuclear Risks, and Deterrence Strategies

Revise and Resubmit, International Organization

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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.

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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; Bueno 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; Bueno 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 every year (in absolute terms) preparing for a conventional assault 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, despite the possibility of Western intervention. 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, thus capturing the essence of brinkmanship (Carter 2010; Gurantz and Hirsch 2017; Spaniel 2019*b*; Yoder 2019*b*; Baliga, Bueno de Mesquita and Wolitzky 2020; Di Lonardo and Tyson 2022). In the model, establishing a strong conventional military force posture not only impacts the balance of power and deterrence, but also influences the duration of the conflict in ways that affect the likelihood of a nuclear exchange.

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 possibility that a conventional conflict could escalate into a nuclear exchange, all actors fare worse in a conventional-but-now-potentially-nuclear conflict, making 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 to maintain their deterrent threat.

Second, I find that actors in the nuclear era will sometimes demonstrate restraint, while at other times they will act more aggressively and decisively 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 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. These findings offer a microfoundation for understanding why the Western defense of West Germany was supported by nuclear weapons, while the defense of nations outside the European theater may have required additional resources once nuclear risks were introduced.

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, Bueno 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 below). Additionally, this paper is naturally related to the topic of nuclear proliferation (Bas and Coe

2012, 2016; Lanoszka 2018; Spaniel 2019*a*; Mehta and Whitlark 2018, 2021), 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. 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. Adding conventional forces can narrow the gap between two sides if the defender's capabilities approach the challenger's, or widen it if the defender's capabilities surpass the challenger's.

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 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; 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 these risks are typically ascribed 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 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

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[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.

[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.

as to make the conflict one-sided and decisive, there will be little risk of a nuclear escalation.[3] 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 $0 < p_0 < p_1 < 1$; while substantively we might expect the gap between p_0 and p_1 to be small, the results will hold for any p_0 and p_1 satisfying the inequality.

2. C selects whether to challenge or not.[4] 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).

I include the game form in Figure 1.

Conflict is a reduced-form, stochastic process that will end in one of three outcomes: C wins a conventional victory, D wins a conventional victory, or there is a catastrophic nuclear exchange. Because actors do not "move" within the conflict, conflict duration and outcome will be shaped

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[3] Note that setup, for example, does not describe a setting where a more significant first strike always carries a greater risk of nuclear escalation.

[4] Similar to Powell (2015), only one side (here D) can arm. It C could arm, this would sometimes leave the results unchanged, but, under some parameters, would undermine the results discussed in the Remarks. Simply, if C could arm, and changes in n produced significant changes in how C would optimally arm, then the Remarks could break down. See the Appendix for a further discussion.

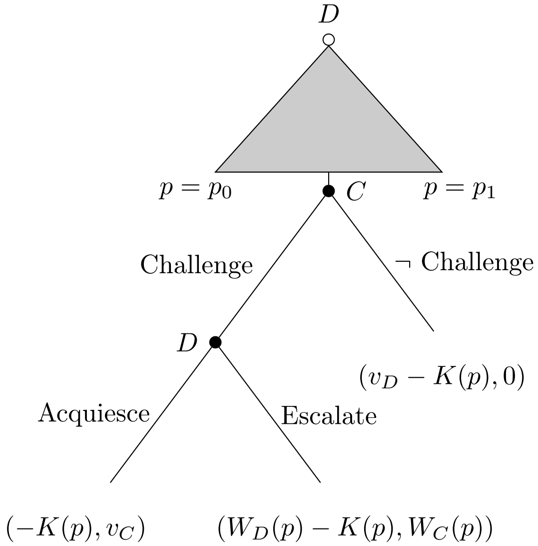

Figure 1: The game tree

by endogenous selections (in p) and several exogenous hazard rates, which characterize the likelihood of a given conflict outcome occurring at any point in time.[5]

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, are fighting near critical nuclear infrastructure (Posen 2014), or, for the conflict below the level of a strategic nuclear exchange, are using tactical nuclear weapons (with some caveats; see Section 7.3). 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). The parameter $\alpha > 0$ allows scaling that grants more flexibility to the conventional conflict hazard rate. Together, this means that $h(p) = n + \frac{\alpha}{p(1-p)}$ is the hazard rate

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[5] Put another way, I am not treating conventional conflict as a continuous-time, war-of-attrition-type game like in Nalebuff (1986). This assumption should be relaxed in future research, but the hazard rate structure is still included here to allow for flexibility in conflict costs and risk *vis a vis* conflict duration.

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.

If the game ends with a nuclear exchange, D's and C's expected payoffs are $-N_D < 0$ and $-N_C < 0$, respectively. If the conflict ends conventionally, D wins with probability p, and C wins with probability $1 - p$. Similar to Powell (2015), because there is no repeated play, p can most cleanly be thought of as mobilization levels within a crisis.[6] 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

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

and D's expected utility—without considering arming costs $K(p)$—is

$$W_D(p) = \frac{n}{h(p)} * (-N_D) + \frac{\alpha}{h(p)p(1-p)}\left(pv_D\right) - \frac{c_D}{h(p)}.$$

2 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

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[6] Because the selected p occurs at the beginning of the crisis, with some caveats, the model could also support the interpretation that some of p is a long-term force deployment aimed at deterring C, so long that this can be manipulated in such a way to model resolve.

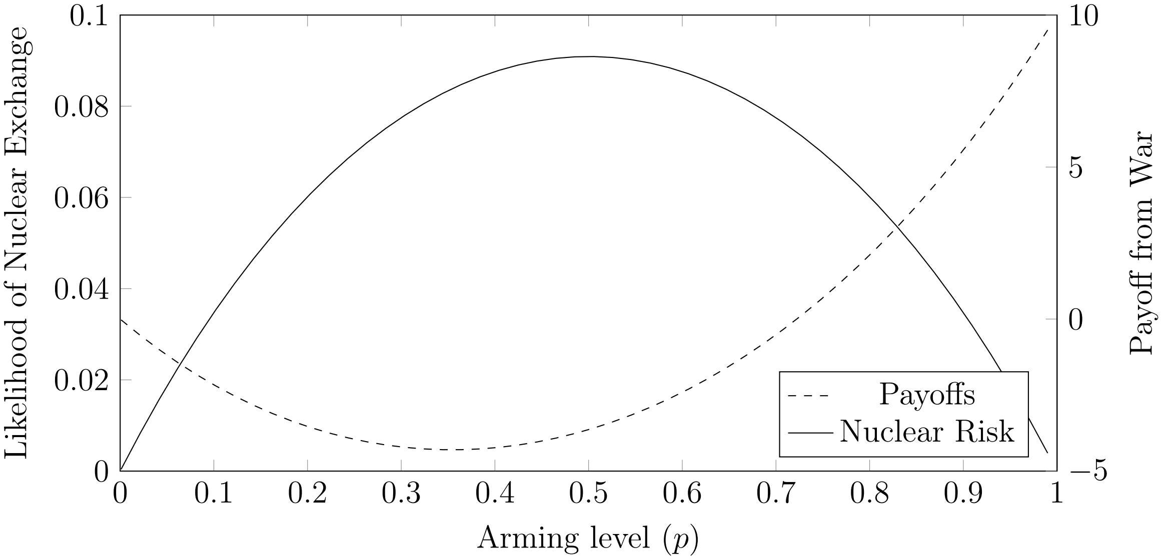

Figure 2: Nuclear risk and payoffs with the costs of arming excluded. Parameters for this figure (and all other figures) are in the Appendix.

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 switches to increasing in p until reaching p_1.

3.2 Comments on Model Assumptions

This is a deterrence model, like Powell (2015), Gurantz and Hirsch (2017), Di Lonardo and Tyson (2022), Baliga, Bueno de Mesquita and Wolitzky (2020), and others. The model setup is most similar to Powell (2015), but differs in two key respects. First, in the model presented here, nuclear risk in a conventional conflict is determined indirectly through the defender's arming level. In Powell, the defender is able to directly manipulate the level of nuclear risk within a conventional war without altering its likelihood of winning in the conventional war. Second, Powell finds that adding conventional forces to a conflict always increases the risk of escalation. Unlike this model, Powell does not consider that a swift and decisive deployment might reduce the likelihood of a nuclear exchange by preventing a prolonged conflict. Naturally, these different assumptions lead to different results from Powell, as highlighted throughout the paper; for more details on this, see the Online Appendix.

This paper also has benefited from decades of iterations of models of nuclear deterrence (Schelling 1980; Nalebuff 1986; 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*a*), 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*; Baliga, Bueno de Mesquita and Wolitzky 2020; Schram 2021*a*,*b*).

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. After all, in this model, nuclear escalation risk is generated through conventional conflict rather than through an actor's outright decision to launch a strategic nuclear missile when faced with the prospect of an opponent seizing the asset (the latter of which is not allowed in the model). 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. 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).

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]

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

To remain willing to fight when challenged, D must select greater conventional force postures p^D if c_D, N_D, and n increase and α decreases. Why? As some intuition, increasing c_D, N_D, and n all increase the costs from war, and decreasing α makes the nuclear outcome option more likely; faced with these higher costs, D would only be willing to fight when D wins the asset with higher likelihood. Importantly, a similar logic holds for when v_D is lower, as this requires D to arm more to remain willing to fight.

For deterrence condition (b) to be met, D must establish a sufficient force posture so that if D escalates, C fares poorly enough 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

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

The value p^C is decreasing in c_C, n, and N_C, and increasing in α and v_C. As intuition, as C's

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[7] Formally, p^D solves $0 = W_D(p)$.

[8] Formally, p^C solves $0 = W_C(p)$.

costs from going to war increase (n, N_C, and c_C all increase and α decreases) or C's valuation of the asset (v_C) decreases, C is less willing to go to war, which makes it easier to deter C at lower force postures.

Together, for deterrence, D will select the smallest force posture where both D's war participation 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 cost 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] When D does best fighting, D optimizes by setting $p = \hat{p}$, where

$$\hat{p} \in \underset{p \in \left[max\left\{p^D, p_0\right\}, min\left\{p^C, p_1\right\}\right]}{argmax} \left\{W_D(p) - K(p)\right\}$$

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 $\hat{p} = p^C$—when p^C is the corner solution to the optimization—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]

In addition to assuming that equilibria must be subgame perfect, I also assume the following:

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

[10] The set of feasible p values that result in fighting 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 does not occur in equilibrium.

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

Complete Information Game Assumption: *There is a feasible level of arming where D is willing to fight. Formally,* $p^D \leq p_1$.

This assumption rules out a fairly uninteresting case. If $p^D > p_1$, then D's war participation constraint is never met, making deterrence impossible and outside of the scope of interest.

With this assumption 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, 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* $p^D \geq p_0$, $V_D - K(p^C) \geq 0$ *and* $V_D - K(p^C) \geq W_D(\hat{p}) - K(\hat{p})$, *or* $p^D < p_0$ *and* $V_D - K(p^C) \geq W_D(\hat{p}) - K(\hat{p})$, *then D selects* $p^* = p^C$ *(D deters C).*
  - *If* $p^D \geq p_0$, $0 > V_D - K(p^C)$, *and* $0 > W_D(\hat{p}) - K(\hat{p})$, *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* $p^C > p_1$,

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[12] This equilibrium is unique insofar that when players are perfectly indifferent over actions, they only play one action (as defined). For example, when C is indifferent between acquiescing and fighting, C always acquiesces.

  - *If* $W_D(\hat{p}) - K(\hat{p}) \geq 0$*, or* $p^D < p_0$ *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* $p^D \geq p_0$ *and* $V_D - K(p^D) \geq 0$*, or* $p^D < p_0$*, then D selects* $p^* = max\left\{p_0, p^D\right\}$ *(D deters C).*
  - *Otherwise, D selects* $p^* = p_0$ *(D acquiesces).*

Proofs are given in the appendix.

Figure 3 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).

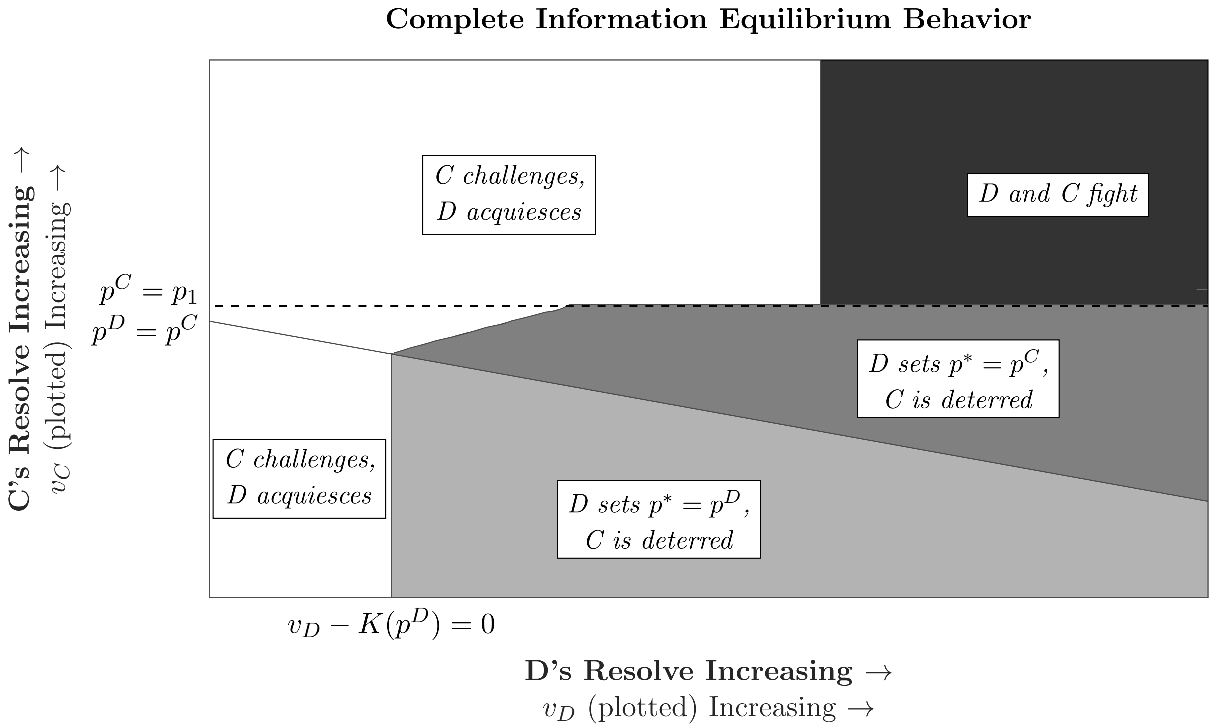

Figure 3: Equilibrium spaces in the complete-information deterrence game. For all white spaces, C will challenge and D will acquiesce. For all light-gray spaces, C will be deterred. And for all dark-gray spaces, C and D will fight.

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

5 Results

Before discussing the results, it is worthwhile describing how to practically interpret comparative statics on parameter n. Most simply, the advent of nuclear weapons increased n. Before the nuclear era, competition and conflict between great powers carried no risk of an accidental nuclear launch because these weapons did not exist ($n = 0$); within the nuclear era, such risks now exist ($n > 0$). Additionally, within the nuclear era, if states use decentralized nuclear launch decisions, rely on (potentially faulty) automated systems to determine when to launch a nuclear weapon, or expand their arsenals (thus creating more "moving parts" that could fail), then conflicts involving those states will take on higher levels of nuclear risk (Sagan 1994; Sagan and Waltz 2003). Thus, changes in n can also approximate the changes that states make to their nuclear command and control infrastructures.

To further preview the analysis, the comparative statics in Remarks 1, 2, and 5 depend on whether C's war cost constraint binds (when $p^C > p^D$) or D's war participation constraint binds (when $p^C < p^D$). Before discussing these Remarks, it is worthwhile describing when, substantively, C's war cost constraint would be expected to bind. This is perhaps clearest when C and D are roughly similar across all parameters, and when both C and D place relatively high value on the asset. Based on how the terms are defined, if D places a high value on the asset (high v_D), then p^D will be lower; and, if C places a high value on the asset (high v_C), then p^C will be greater. Together, this implies that for jointly-high-value assets, C's war cost constraint is more likely to bind.[13] As one example of this, consider NATO as D, the Soviet Union as C, and West Germany as the high-value asset. NATO plausibly placed a high value on keeping West Germany outside of the Eastern Bloc, both for direct strategic reasons and for maintaining the "status quo" of European borders (Brodie 1965; Jervis 1979*b*; Schelling 1966). And, plausibly, the Soviet Union also viewed West Germany as a high-value asset; in addition to the strategic value of expanding the Eastern Bloc, Stalin's concerns over West Germany's move into NATO and its rearmament could be addressed through the Soviet Union reunifying and controlling all of Germany (Trachtenberg 1999, 109-112). Together, in this example, the Soviet Union's war cost constraint would plausibly bind.

It is also useful to know when D's war participation constraint would be expected to bind. This is clearest when both D and C are similar and both place relatively low value on the asset. If C and D place low value on the asset (low v_C and v_D), this makes p^C low and p^D high, which together can imply that D's war participation constraint is more likely to bind. Substantively, this could describe many Cold War crises or proxy wars that occurred in countries with newer borders or in regions that were, while still important, outside of the prioritized European theater. Thus, in those cases, D's war participation constraint would plausibly bind.

For the results that hinge on whether p^C is bigger than p^D (or vice versa), comparative statics are clearest when both sides are similar and when both sides place high value or low value on the asset.[14] Interestingly, in cases where one side places a high value on the asset and the other side places a low value on it, then it is more difficult to determine whether p^C or p^D is bigger,

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[13] This same rationale also holds when D and C both have low costs to fighting conventionally.

[14] Or, similarly, when both sides have high conventional conflict costs or low conventional conflict costs.

which in turn makes understanding the effects of changes in n on outcomes more difficult.[15] And, naturally, these generalizations—like that D's war participation constraint is more likely to bind when D and C care less about an asset—may break down when C and D are different in terms of conventional capabilities.

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 should a conflict occur. For this reason, added nuclear instability can cut both ways, making deterrence easier or more difficult.

Remark 1: *Nuclear weapons and nuclear risk are imperfect substitutes for conventional forces. Formally, if n increases and D's war participation constraint binds ($p^C < p^D$), then D must increase their conventional force posture to maintain deterrence. Alternatively, if n increases and C's war cost constraint binds ($p^C > p^D$), then D can select a lower conventional force posture and still maintain deterrence.*

Recall that for deterrence, both D's war participation constraint and C's war cost constraint must be met (formally, D must set $p = max\left\{p^C, p^D\right\}$). Consider when D's war participation constraint binds ($p^D > p^C$). Here, to deter C, D must arm to the level where D is willing to fight. As nuclear instability increases, in order for D to continue being willing to fight, D must attain a better expected outcome when the conflict ends conventionally to compensate for the greater risk of a nuclear exchange. To achieve this better conflict outcome and maintain deterrence, D must select a greater initial force posture, or greater p.[16] Alternatively, consider when C's war cost constraint binds ($p^D < p^C$). Here, to deter C, D must arm to the level where C perceives war as prohibitively costly. As the risk of nuclear escalation increases, C does worse in the conflict and wants to challenge less, meaning C will be deterred by a more limited force posture, or lower p.[17] Together, depending on whether D's war participation constraint or C's

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[15] Formally, suppose C and D are similar, but D places a high value on the asset and C places a low value on the asset. Because p^D decreases as v_D increases and and p^C decreases as v_C decreases, p^D and p^C are moving together, making it more difficult to determine whether p^C is bigger than p^D.

[16] By definition, p^D is increasing in n.

[17] By definition, p^C is decreasing in n. Also note that this analysis (and the analysis in Remarks 2 and 5)

war cost constraint binds, increasing nuclear instability could result in D selecting greater or lower force postures for deterrence.

Of course, whether nuclear risk makes deterrence easier or harder—whether p^C is bigger than p^D or vice versa—can be substantively identified, as discussed earlier. If C and D are similar and both place relatively high value on the asset, then C's war cost constraint binds and added nuclear instability makes deterrence achievable at lower force postures. And, similarly, if C and D are similar and both place relatively low value on the asset, then D's war participation constraint binds, and added nuclear instability requires D to raise their conventional force posture for deterrence. Importantly, these results describe effects following changes in nuclear instability. They do not imply, for example, that D prefers crises when both v_D and v_C are high—it is still the case that deterrence is cheapest to achieve when v_D is high and v_C is low. Rather, Remark 1 speaks to the marginal effect of nuclear weapons on the level of arming needed for deterrence. I go into more details about what this means substantively immediately below and then later in context of the Cold War (Section 6.1).

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.[18] Sometimes, for example, in conflicts over assets where both C and D place low value on the asset, 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.

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assumes n does not increase so much that it makes $p^D > p^C$ (unless specified otherwise).

[18] In an alternative setting, where one state faces an existential threat and would use strategic nuclear weapons rather than allow an adversary to claim an asset, the Waltz (1981) comments seem fully correct. Note that neither actor has this option in the model.

5.2 Welfare Effects When Conflict Does Not Occur

Increasing nuclear instability can impact overall ex-ante welfare outside of changing how conflict plays out.

Remark 2: *Increasing nuclear instability can either increase or decrease equilibrium conventional arming levels, thus raising or lowering overall ex-ante welfare. Formally, suppose D deters C in equilibrium. If n increases and D's war participation constraint binds ($p^C < p^D$), then ex-ante welfare decreases. Alternatively, if n increases and C's war cost constraint binds ($p^C > p^D$), then then ex-ante welfare increases.*

Consider what increasing nuclear instability means for welfare[19] when D optimally deters C. As discussed in Remark 1, as nuclear instability increases, D may select 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. Here, increasing nuclear instability can constitute a Pareto improvement when D can deter C by arming less, as happens when D and C are similar and both place relatively high value on the asset (in other words, when C's war cost constraint binds). And, increasing nuclear instability can be Pareto inefficient when D must arm more to deter C, as happens when D and C are similar and both place relatively low value on the asset (when D's war participation constraint binds).

Note that the paragraph above is limited to discussing how n affects force posture and welfare when D deters C in equilibrium. Moving outside of deterrence, the comparative statics become more complex. For example, suppose under some n D optimally deters C and $p^D > p^C$. If n increases, D may not want to pay the higher costs to deter C any longer and may instead prefer to acquiesce; here increasing n would then decrease D's arming level and could improve welfare.[20] To elaborate on these comparative statics, in the Appendix, I include an expanded discussion on the general effects of changing n on arming and welfare.

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 (Bueno de Mesquita and Riker 1982). In

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[19] In terms of the model, "welfare" refers to "ex-ante welfare."

[20] Technically, transferring the asset from D to C could constitute a welfare gain or loss if one actor values the asset more. This scenario will always constitute a welfare improvement if C and D value the asset the same.

contrast, nuclear pessimists typically note that, even if nuclear weapons reduce the likelihood of war, whenever war occurs, 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, while deterring direct threats to critical assets may be cheaper, establishing extended 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, consider 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 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.[21]

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[21] 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.

Section 4 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 and Arming Incentives

In the nuclear era, the defender seeks to avoid prolonged conflicts that carry a high risk of a nuclear exchange. To accomplish this, when the defender prepares for a fight, they may select a more aggressive or a less aggressive force deployment.

Remark 4: *Under select conditions, as nuclear instability increases, D is incentivised to make conflict shorter and more decisive, and, to accomplish this, may select a more or a less aggressive force posture. Formally, assume the solution set to* $\hat{p}$ *is singleton and both actors place high value on the issue.*[22] *Consider nuclear instability parameters* n' *and* n''*, where* $n' < n''$*. If* $p^*(n')$ *is small enough, then* $p^*(n') > p^*(n'')$*. And if* $p^*(n')$ *is large enough, then* $p^*(n') < p^*(n'')$*.*

Figure 5 visualizes one version of Remark 4. The left graph plots the equilibrium force posture (y-axis) for a range of v_D values (x-axis) where, for this set of parameters, C and D will fight in equilibrium. The open dots plot the equilibrium force posture levels when the likelihood of a nuclear exchange is non-existent ($n = 0$), and the closed dots plot equilibrium force postures when nuclear instability is positive ($n = 0.015$). The right graph plots the expected time in conflict[23] (y-axis) for the same v_D values (x-axis) and nuclear instability parameters as the left graph.

Consider the left plot in Figure 5. For the lowest v_D values (for example $v_D = 35$), as n increases (moving from open to closed dots), equilibrium arming levels decrease ($p^* \approx 0.38$ for $n = 0$, and $p^* \approx 0.34$ for $n = 0.015$). In contrast, for the highest v_D values (for example $v_D = 49$), as n increases, equilibrium arming levels increase ($p^* \approx 0.73$ for $n = 0$, and $p^* \approx 0.8$ for $n = 0.015$). Together, increasing the likelihood of a nuclear exchange generates different effects on arming

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[22] I elaborate on this and offer a more technical version of Remark 4 in the Appendix.

[23] Using the hazard rate setup, expected time in conflict is $\frac{p^*(1-p^*)}{np^*(1-p^*)+\alpha}$, where p^* is the equilibrium force posture.

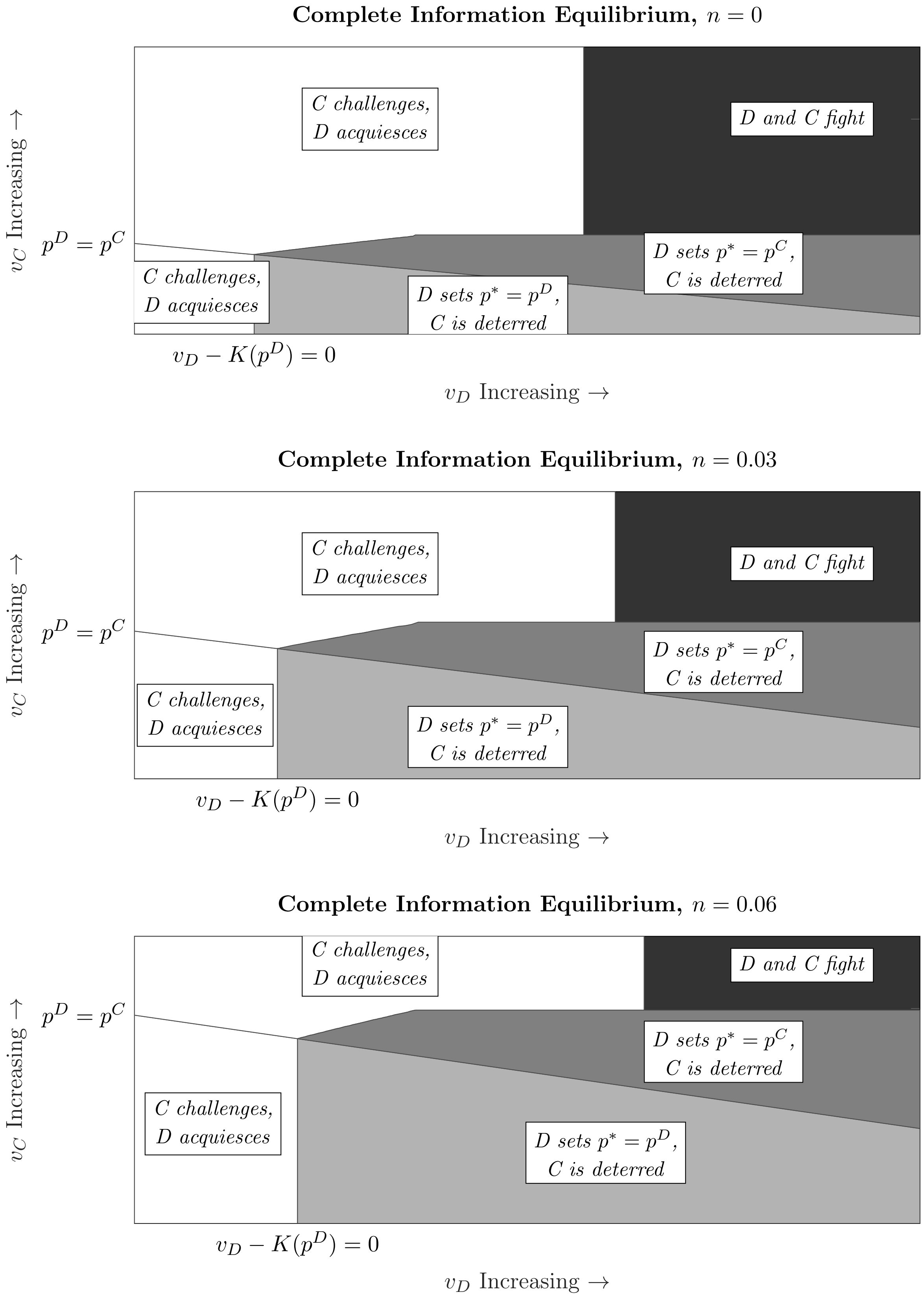

Figure 4: Equilibrium spaces in the complete-information deterrence game. Instability parameter n increases from top to bottom.

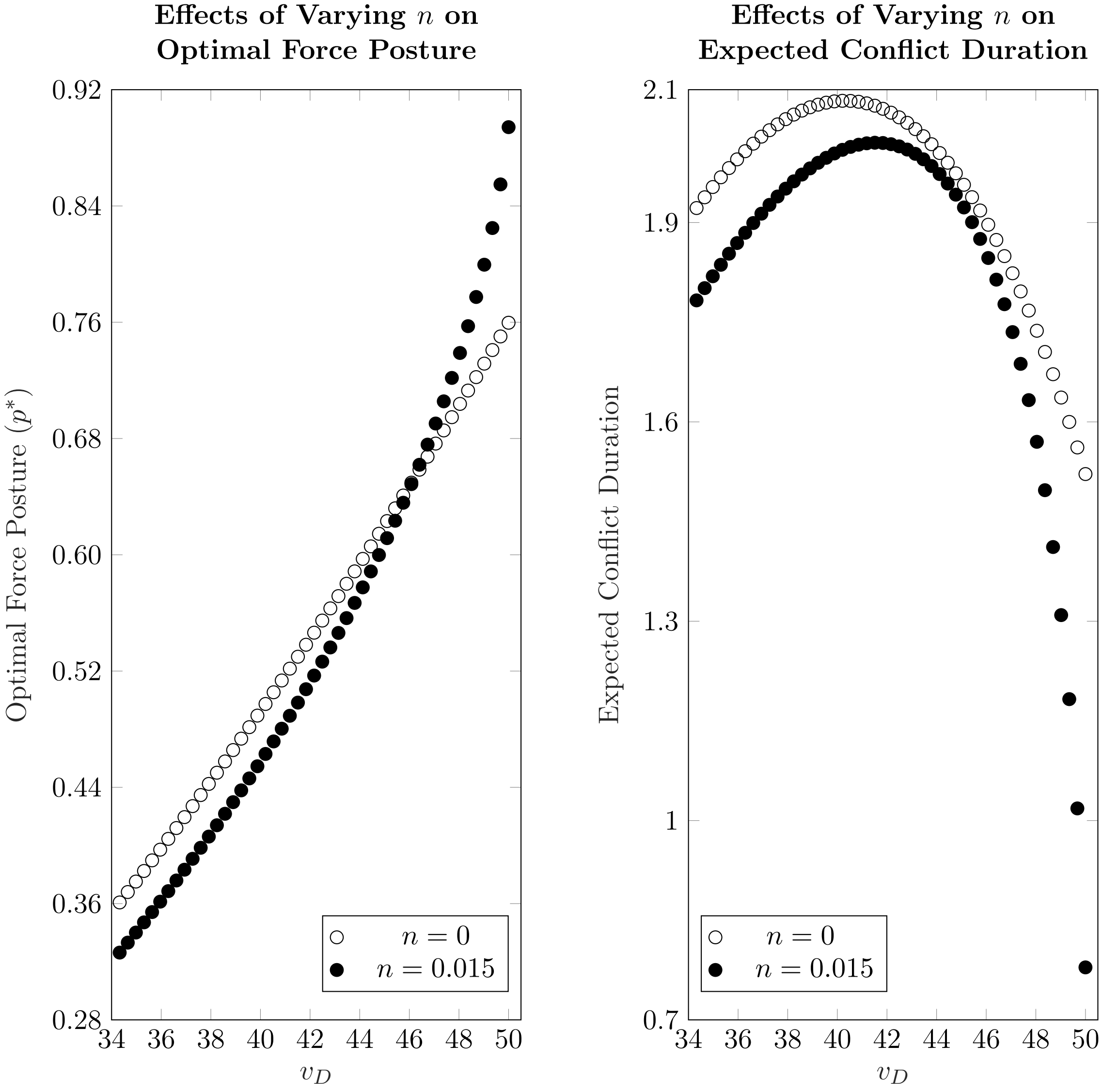

Figure 5: Optimal arming levels (y-axis, left) and expected conflict duration (y-axis, right) at different asset valuations (x-axis) for D at different levels of nuclear instability. Increasing the nuclear instability parameter from $n = 0$ to $n = 0.015$ can result in D arming less (for low v_D) or more (for high v_D).

outcomes, but these decisions are driven by the same underlying incentives. Recall how added force posture generates more risk when it makes both sides more equal and less risk when it makes both sides less equal. Following that logic, for any initial arming level below $p = 0.5$ for $n = 0$, adding nuclear risks presents new costs to staying in conflict, which incentivises D to arm less to make conflict shorter (as it was in the $v_D = 35$ example).[24] And, for any initial arming level above $p = 0.5$ for $n = 0$, adding nuclear risks similarly presents new costs to staying in conflict, which now incentivises D to arm more to make conflict shorter (as it was in the $v_D = 49$ example). As is shown in the right plot, these different arming responses to the introduction of risk both work to shorten the expected conflict duration.

However, as Remark 4 states (and the Appendix further discusses), the logic of the previous paragraph holds for large or small initial (i.e. under $n = 0$) arming levels. For initial arming values around 0.5, competing effects can dominate arming decisions. In addition to introducing new costs to more prolonged conflicts, increasing n makes D's arming less productive by decreasing the likelihood that D attains the asset, and increasing n mechanically shortens conflict duration, which in turn influences D's anticipated conventional war costs. Furthermore, the marginal effects of changes in p on expected conflict duration are the smallest around $p = 0.5$, meaning D would be least willing to try to manipulate p to shorten conflict here. While at low or high initial arming values we would anticipate movement towards the extremes with increases in n, for intermediate values, comparative statics become more complex. This is visualized in the left graph. For example, at $v_D = 42$, the arming level under $n = 0$ is $p^* \approx 0.54$, and the arming level under $n = 0.015$ is $p^* \approx 0.52$.

Powell (2015) finds that strategic states always respond to greater nuclear instability with more restrained levels of force in conflicts, as was observed in the Kargil War (1999). While under some parameters my results echo Powell, while at other times I find that defenders commit more force to a conflict when faced with greater nuclear instability and greater nuclear costs. Why? Here (unlike in Powell), the defender can avoid prolonged conflicts by reducing military parity through greater or lower levels of arming. Substantively, this paper highlights a different mechanism for occurrences of low-level conflict in the nuclear era. Powell suggests

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[24] Because expected time in conflict is $\frac{p^*(1-p^*)}{np^*(1-p^*)+\alpha}$, the marginal effect of increasing p^* is positive for all $p < \frac{1}{2}$ and negative for all $p > \frac{1}{2}$.

that conventional conflicts with nuclear risk will have lower levels of force deployed to minimize escalation likelihood. I find that conventional conflicts with nuclear risk will be more decisive and less prolonged, which may involves less or more aggressive force deployments to prevent nuclear escalation in a protracted conflict. This means that my results can offer a theoretical grounding for both restraint and excess in force deployments in response to nuclear risk. I discuss the substantive implications further in Section 6.2.

5.5 Deterrence Failure and Nuclear Instability

Remark 5: *Increasing nuclear instability can increase or decrease the likelihood of deterrence failures. Formally, suppose D deters C in equilibrium and* $p^D > p^C$*; if* n *increases, then the arming level required to deter C increases, and D may optimally switch to acquiescing. Now suppose D acquiesces to C in equilibrium and* $p^D < p^C$ *holds; if* n *increases, then the arming level required to deter C decreases, and D may optimally switch to arming up to the level that will deter C.*

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, 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 to that new level and establish deterrence. Ultimately, whether D experiences more or fewer deterrence failures following increases in nuclear instability depends on the underlying conditions of the case.

It is perhaps counterintuitive that when both C and D don't place high value on the asset (i.e. $p^C < p^D$), then deterrence failures are more common following increases in nuclear instability. Reasonable readers might question why C would challenge over assets that it does not highly value, especially in the face of increased nuclear instability. Ultimately, that intuition is incomplete because it does not also take into account D's limited willingness to fight. To keep C from challenging, not only must C find war to be prohibitively costly, but also D must be willing to fight. If D does not place a high value on the asset, then D's willingness to fight becomes the critical factor, as C knows it could challenge without D escalating. In this setting, while C does not value the asset highly and knows that war could more easily lead to catastrophic outcomes when n is elevated, C also knows that, with this elevated n, D may never start the war to begin with, thereby allowing C to easily take the asset.

6 Empirical Implications

6.1 Challenges of the New Look Doctrine

Remarks 1, 2 and 5 offer formalized insight into the frustrations of the Eisenhower administration. Eisenhower's New Look national security policy aimed to establish robust deterrence and minimize 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,[25] 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 or massive retaliation to deter small transgressions. These difficulties have been discussed in previous scholarship, and by Eisenhower himself (Gaddis 2005; Freedman 1989; Trachtenberg 1999). But Remarks 1, 2, and 5 highlight additional nuance. If conventional forces function as Schelling (1966) discussed—escalating the risk of a nuclear exchange—then conventional wars in the nuclear era take on a dimension. In this era, for deterrence, the defender must be willing to fight despite the underlying nuclear risk, which may demand an over-investment in conventional forces beyond what would be required without the nuclear risk. Consequently, deterrence may perversely become more expensive.

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[25] 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).

The theory presented here offers predictions on whether the nuclear revolution made deterrence easier or harder. The earlier Remarks suggest that added nuclear instability makes deterrence easier, cheaper, and less prone to failures in settings where both challengers and defenders place high value on the asset. Substantively, this could describe the defense of Western Germany, especially West Berlin. The theory aligns with claims that for much of the Cold War, territories like West Berlin were vulnerable to a Soviet invasion, but Western deterrence was bolstered by the underlying nuclear risk of a conventional confrontation. (Schelling 1966, 46-48). Put another way, if nuclear weapons had never been created, the defense of Germany would be even more expensive, and deterrence failures could have been more pervasive in that conflict theater. Similarly, the theory suggests that added nuclear instability makes deterrence harder in settings where both challengers and defenders place relatively low value on the asset. Plausibly, this could apply to crises in the Cold War outside of the strategically prioritized European theater, suggesting that the nuclear revolution made extended deterrence in Latin America, Africa, and Asia more difficult. As possible evidence of this, much of the global instability and conflict that occurred during the Eisenhower administration (and into the Cold War) occurred in the "periphery" (Acharya 2002; Westad 2005), where the theory suggests that maintaining deterrence is most difficult.[26] Together, this paper suggests that while the New Look policy of relying on nuclear weapons and risk plausibly contributed to some of the deterrence successes that the Eisenhower administration faced, it also potentially contributed to some of the increased expenditures and deterrence failures as well.[27]

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

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

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[26] Note that many potential confounding factors could also create this pattern in the data. Many of the revolutions and civil conflicts of the Cold War could be seen as a continuation of anti-colonial movements of the early twentieth century, suggesting this trend was more a continuation of the past. That being said, broad Cold War politics still shaped these, as many of these conflicts intentionally took on pro-/anti-communist identities (Westad 2005).

[27] Admittedly, there is some subtlety here that falls outside the predicted behavior in the model. The model predicts that when $p^C < p^D$, deterrence failures take the form of C challenging and D acquiescing. Instead, several proxy wars in the Cold War took the form of limited conflicts. While some of these limited conflicts could be interpreted as a kind of "acquiescing," future research should consider more flexibility in responses that could better capture this behavior.

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). Eight days later, Soviet forces 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, believing the crisis could spread to other Soviet states (Kramer 1998) and could potentially 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 deployment, 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 a challenge 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, after the invasion, when Khrushchev's son asked his father 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).

The analysis suggest that nuclear instability can incentivize both less aggressive military maneuvers, as seen in the Kargil War (1999), 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). Then, 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, New Delhi's actions eliminated this status, dismantled the 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 to any potential challenges, New Delhi sent between 40,000 and 45,000 additional soldiers and police forces to Jammu and Kashmir, bringing the number of Indian troops in the region to approximately 100,000, (Bose 2021),[28] implemented a lockdown of mobile and internet communications, and rolled out extensive and protracted curfews.

India's dramatic policy shift inflamed tensions in a long-simmering regional conflict that has been punctuated by both direct military confrontation and third-party-backed terrorist attacks. While we do not have access to the deliberations of Narendra Modi and his inner circle, it is reasonable to assume that Modi and his advisors believed that Pakistan would challenge the abrogation, potentially through conflict. In the past, Pakistan's Inter-Services Intelligence (ISI) has backed terrorist groups who have conducted attacks over less dramatic changes to Kashmir's politics (Ahlawat and Izarali 2020; Chohan and Aamir 2020). And, in the weeks after India's actions, Imran Khan publicly threatened a confrontation; in a televised address, Khan stated "Whether the world joins us or not, Pakistan will go to any lengths and its people will support [Kashmiris] till their last breath" (Ahlawat and Izarali 2020). And, while past behavior or messaging may not be predictive of behavior in a crisis, after the abrogation, scholars and policymakers suggested that Pakistan, in response, may support terrorists or issue nuclear threats (Kazmin and Bokhari 2019; Ahlawat and Izarali 2020; Chohan and Aamir 2020).[29]

While Pakistan challenging the abrogation was a possibility, after India flooded Jammu and Kashmir with security forces, Pakistan faced limited options. Pakistan would struggle to directly confront India in Kashmir; when pressed by hawkish opposition members in Parliament to respond to India's actions, Khan replied, incredulously, "What do you want me to do...Should I go to war with India?" (Nasir 2019; Ahlawat and Izarali 2020). Additionally, Pakistan's more common response of supporting militant groups in Kashmir seemed likely to fail given the circumstances. Given the concentration of security forces, militant or terrorist attacks seemed unlikely to dislodge Indian forces or change politics. Altogether, by positioning the force deployment that they did, India seemed prepared to quickly handle any challenge that Pakistan presented. Once again, consistent with Remark 4, it seems plausible that the potential nuclear risks from this crisis incentivized India to act more decisively, ensuring that any challenge would

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[28] Chohan and Aamir (2020) discusses how this made Kashmir one of the most militarized zones in the world, with a 1:8 ratio of security-personnel to civilians.

[29] A few weeks after abrogation, Khan raised the possibility of a direct confrontation with nuclear risks in a New York Times opinion piece (Khan 2019).

be addressed quickly and without a greater risk of escalation.

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,[30] 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 greater levels of nuclear instability (i.e. $n_D > n$), and other times D will select 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 nuclear instability levels will expand the parameter range where D can deter C.

These results offer additional insight into decision making during Cold War. There are several explanations for why (for example) the United States did not use tactical nuclear weapons or lean more heavily on nuclear threats in Vietnam (Tannenwald 2006, 2007); this question could also apply to other proxy wars, like the Soviet invasion of Afghanistan. This extension can offer a new explanation that is grounded in the fundamentals of deterrence. In proxy wars where both sides place low value on an asset, it is more likely that D's war participation constraint will bind. And, when D's war participation constraint binds, adding nuclear risks is counterproductive for deterrence, as re-establishing deterrence would require an expanded conventional force posture. Substantively, in proxy conflicts outside of Europe, trying to manipulate nuclear risk or using

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[30] Here I am comparing the results from the game where n is exogenous to the game form where n is endogenous.

tactical nuclear weapons would be a losing proposition for defenders, as doing so would require them to deploy an expanded force posture (that may be prohibitively costly) in order to deter their adversaries.[31]

7.2 Bargaining

The model in the main text was a deterrence model, much like Carter (2010), Gurantz and Hirsch (2017), Baliga, Bueno 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.[32]

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 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 influences and changes incentives concerning conventional capabilities, because relative conventional capabilities now influence not only prospects for conventional victory or defeat in a war, but also nuclear risks. Several states have nuclear-powered submarines and aircraft carriers. Additionally, it is possible that one day tactical

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[31] Naturally, this logic is complicated if tactical nuclear weapons were highly effective at destroying adversaries.

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

nuclear weapons will be deployed on the battlefield as part of a conflict below the threshold of a strategic nuclear exchange. 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 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 competing effects. Without additional structure, it is not possible to know whether the nuclear peace result will be undermined. Still, given the empirical evidence 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 analysis to an essentially unique perfect Bayesian Nash equilibrium that satisfies the intuitive criterion (Cho and Kreps 1987). 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

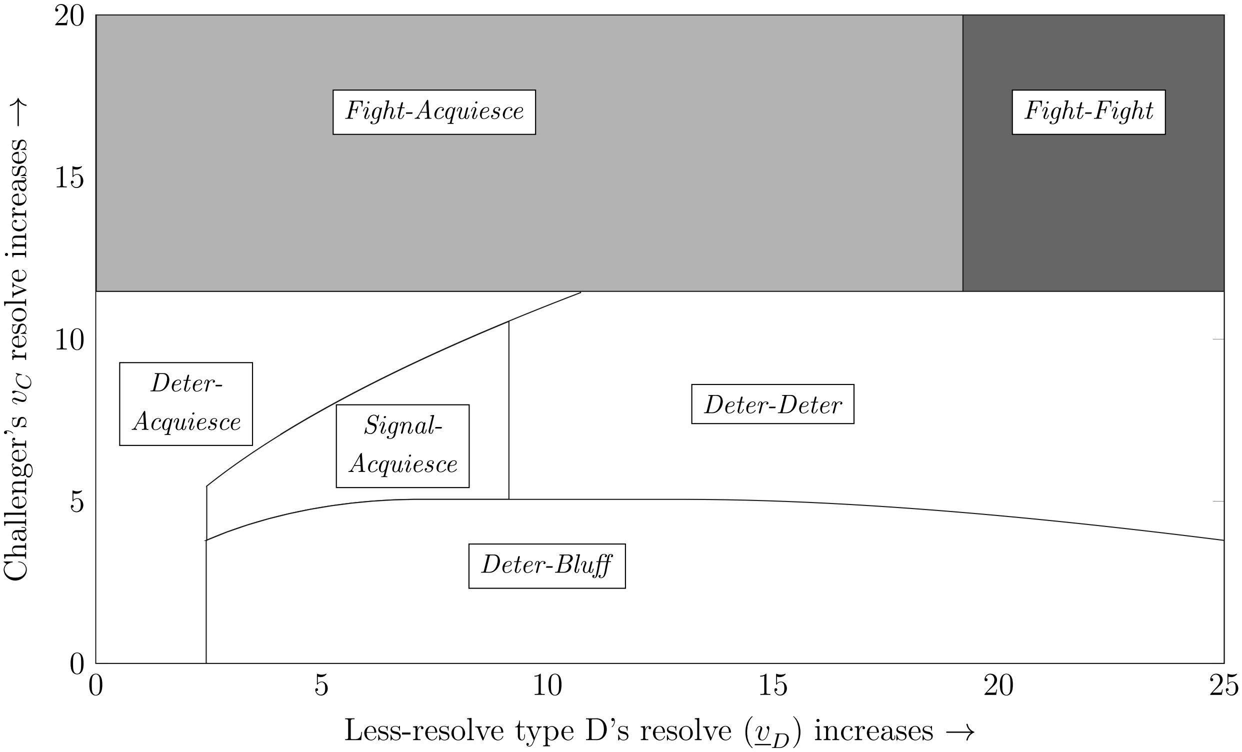

Figure 6: Equilibrium spaces in the incomplete-information game. The x-axis varies $\underline{v}_D$, which is the less-resolve type's valuation of the asset, and the y-axis varies v_C, which is the challenger's valuation of the asset. The darkness of shading represents the likelihood of war. In the 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.

acquiesce, deter, or fight).

I depict the equilibrium spaces in Figure 6. 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, effectively "over-arming" to demonstrate that they are resolved types, which keeps C from challenging (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). 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 $\bar{p}$.[33] 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.[34] Within the parameter set where D signals, arming as a costly signal of resolve always works in that high-resolve defenders can always achieve peace through deterrence.

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, 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

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

[34] Naturally, this supposes that $\bar{p} \geq p^C$.

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 costly signal of a robust conventional force posture. In contrast, Powell (2015) finds that resolved defenders cannot fully deter challengers by manipulating nuclear risk, rather showing that conflict must sometimes occur as part of a costly signalling mechanism. 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, that defender should signal by manipulating force posture rather than manipulating nuclear risk (as in Powell).

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.[35]

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 offers nuance into Eisenhower's spending for deterrence in the nuclear era, suggesting that the defense of West Germany (or even Western Europe more broadly) may have been cheaper due to the nuclear era, while

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[35] With caveats, as discussed above. Additionally, see Kydd (2019) for an excellent analysis of this question. While Kydd similarly considers how nuclear risk both shapes conflict payoffs and war likelihood, Kydd does not consider the effects of nuclear weapons on conventional arming (like this paper does).

spending for deterrence outside of Europe may have been more costly. Admittedly, this is just one effect among many: 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 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.

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; for example, future iterations could consider risks from both the scope of the initial confrontation (like Powell (2015)) and time in conflict. Furthermore, the research considered crises during the Cold War and in Kashmir. Outside of these cases, there is a large class of low-level conflict behavior known as "gray zone conflict" where adversaries deliberately target low-value assets in an effort to break down deterrence (Mazarr 2015; Gannon et al. 2024). future research speak to how the shifting nuclear landscape will affect the proliferation of future gray zone activities.

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A Appendix

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