Nothing to Fear but Fear Itself?
Nuclear Proliferation and Preventive War*

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Abstract

When does nuclear counterproliferation succeed? When does it lead to preventive war? We argue that as the ratio between (i) the effect of nuclear acquisition on the balance of power and (ii) the costs of preventive war increases, counterproliferation becomes more successful but mistaken preventive wars also become more likely. We apply this logic to comparing the dynamics of proliferation during and after the Cold War. During the Cold War, the high costs of preventive war relative to the impact of nuclear acquisition on the balance of power made counterproliferation difficult, leading to the steady spread of nuclear weapons. After the Cold War, however, U.S. power preponderance slows proliferation down by lowering the costs of preventive war relative to the effect of nuclear acquisition on the balance of power. At the same time, mistaken preventive wars – such as, we argue, the Iraq invasion of 2003 – are more likely.

Keywords: deterrence, nuclear weapons, proliferation, polarity, preventive war.

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1 Introduction

In October 2002, pressing the case for invading Iraq, President Bush warned of terrible consequences should Saddam Hussein acquire nuclear weapons. “We refuse to live in fear,” Bush insisted (Bush, 7 Oct. 2002a). This position is emblematic of the centrality of nuclear proliferation in U.S. foreign policy since the end of the Cold War. According to the official discourse, the nonproliferation regime is fragile and its future prospects are bleak. Is this heightened fear of nuclear proliferation justified? Or could it be that an irrational fear of proliferation is leading the United States to pursue an unnecessarily forceful counterproliferation policy?

During the Cold War, the objective risk of proliferation was high, with tens of countries trying to develop nuclear weapons and nine eventually acquiring them. Yet neither the Soviet Union nor the United States proved willing to wage war in order to prevent proliferation. In contrast, since the end of the Cold War, few countries have attempted proliferation and only one – North Korea – has succeeded (see Figure 1). And yet, Washington now regularly considers preventive war to stop the spread of nuclear weapons. Fear of nuclear proliferation led President Clinton to the brink of war with North Korea in 1994; drove President Bush to invade Iraq nine years later; and continues to press grave dilemmas on President Obama concerning Iran. What explains the lower level of proliferation in the post-Cold War? And the concomitant growing centrality of preventive war in U.S. counterproliferation efforts?

— Figure 1 about here —

Unsurprisingly, concerns about nuclear proliferation have percolated through foreign-policy and IR scholarship. In policy circles, no consensus has emerged in the heated debate on the best counterproliferation approach: engagement, containment, or preventive war. In scholarly circles, recent articles have shed light on the dynamics of nuclear proliferation, both from the supply and demand sides, and formal approaches are increasingly used to highlight the determinants of military investment.

Yet, we argue, we are still missing a theory capable of predicting the success of counterproliferation efforts and the likelihood they will result in preventive war. This paper presents a first step in that direction.

In our view, attempts to deter nuclear proliferation are unlikely to succeed when the costs of preventive war are greater than the potential shift in the balance of power produced by
nuclear acquisition. Under such conditions, the threat of preventive war is not credible, and proliferation will occur. When, on the contrary, the costs of launching a preventive war are lower than the impact of nuclear acquisition on the balance of power, the threat of preventive war is credible and counterproliferation should succeed. Since information about a country’s nuclear program is usually imperfect, however, mistaken preventive wars – i.e., wars launched against states suspected of trying to proliferate when they are not – become more likely.

Applying this framework to the nuclear age, we argue that the bipolar world of the Cold War corresponded to a situation where the cost of a preventive war outweighed the effect of proliferation on the balance of power. During that period, both great powers possessed robust retaliatory capabilities (conventional, in the case of the Soviets until 1949). Given their mutually assured retaliation and the relatively small impact of nuclear acquisition on their dyadic balance of power, neither superpower could credibly threaten to stop a member of the opposite bloc from acquiring nuclear weapons.

In the post-Cold War period, however, the balance of power largely favors the United States in any interaction with a non-nuclear state. Nuclear acquisition by another state would therefore have a relatively greater potential effect on the dyadic balance of power, relative to the cost of a preventive war. This allows the United States credibly to threaten preventive war, making counterproliferation more successful. Other states understand that they can improve their standing by acquiring nuclear weapons only should they go undetected. This results in a lower risk of proliferation but also makes for a higher risk of preventive (if mistaken) war, such as the Iraq invasion.

Our argument unfolds as follows. Section 2 reviews the literature and introduces our theory. Section 3 formalizes the theory. Section 4 presents the empirical evidence, discussing the U.S.S.R. (1949) and Iraq (2003) cases. Section 5 summarizes our findings and presents implications. Proofs of the formal results are in the Appendix.

\[\text{Footnote: For the purposes of our argument, “preventive war” includes a whole range of military actions, from “surgical” strikes against a limited set of targets to full-scale war. For a literature review on preventive war, see Levy (2008).}\]
2 Theory and Literature

Our theory is at the crossroads of five IR literatures: deterrence theory, nuclear proliferation, the balance of power, preventive war, and rationalist explanations for war. Specifically, the paper provides a rationalist account of the effect of relative power (and, therefore, polarity) on the likelihood of nuclear proliferation and preventive war. It does so by modeling counterproliferation as a problem of deterrence. In this section, we position our theory in these literatures and highlight its main contributions.

Our argument is designed to capture the interaction between a state that is considering whether to develop nuclear weapons (using deterrence terminology, the target) and another state that is considering whether to resort to military action in order to stop proliferation (the deterrer). This format allows us to ask whether the target is successfully dissuaded from developing nuclear weapons and whether preventive war is likely to obtain. We show that if the impact of nuclear acquisition on the balance of power is lower than the costs of preventive war, proliferation occurs with no preventive war. Intuitively, if the costs of preventive war are greater than the additional concessions that the target will be able to extract from the deterrer as a result of its newly-acquired nuclear capability, preventive war is not a rational option. Under such circumstances, the deterrer’s threat to launch a preventive strike should the target pursue nuclear weapons is not credible. Knowing this, the target develops nuclear weapons undeterred.

If, however, the effect of nuclear acquisition on the balance of power is greater than the cost of preventive war, the deterrer’s threat of military action is credible. In this case, the outcome depends on the quality of the information the deterrer receives about the target’s investment in nuclear weapons. If the investment decision is perfectly observable, neither proliferation nor preventive war occur. The potential proliferator understands that attempting to develop nuclear weapons would result in a preventive strike. Anticipating such an outcome, it decides not to.

In reality, though, perfect observability is unlikely. A state will thus be tempted to develop nuclear weapons if it can avoid detection. Given this strategic incentive, the deterrer cannot commit to reward the target with a favorable peace even in the absence of evidence that the latter is acquiring nuclear weapons. As a result, the target may sometimes develop nuclear weapons and the deterrer may sometimes strike preventively (in game-theoretic terms, the unique equilibrium is in mixed strategies).

Interestingly, when information is imperfect, the likelihood of nuclear acquisition and that
of preventive war depend on the effect of proliferation on the balance of power. The greater this effect, the less likely the target is to acquire nuclear weapons and the more likely the deterrer is to launch a preventive war. As the effect of nuclear acquisition on the balance of power increases, then (everything else being equal) the deterrer is more tempted to declare war to prevent the adverse shift. Therefore, in order to keep the deterrer indifferent between war and peace, the probability of the target deciding to develop nuclear weapons must decrease. At the same time, this greater effect means the target would benefit more from developing nuclear weapons, and would therefore be more tempted to proliferate. Consequently, in order to leave the target indifferent about proliferating, the deterrer must be more likely to declare preventive war. Combining these two results – a lower probability of proliferation and a higher probability of war – we conclude that, as the effect of nuclear acquisition on the balance of power increases, so does the likelihood of mistaken preventive wars.

Our theory depends heavily on measurements of – and comparisons between – the costs of preventive war and the magnitude of the shift in the balance of power resulting from nuclear acquisition. We operationalize and measure such broad concepts the same way policymakers do. We determine the expected outcome of two scenarios: peace, leading to nuclear acquisition by the target; and preventive war, leading to no nuclear acquisition. We then compare the two. As we will see, in the run-up to Soviet acquisition in 1949, U.S. decisionmakers envisioned preventive war to lead to the Soviet conquest of Western Europe (and other areas) with near certainty. Soviet nuclear acquisition, on the other hand, was envisioned as potentially degrading the deterrent effectiveness of the U.S. nuclear umbrella over Europe, but not necessarily to lead to the Soviet conquest of Western Europe. Washington therefore decided that Soviet nuclear acquisition was a less problematic outcome than preventive war with the Soviet Union. Similarly, as we show below, preventive war against Iraq in 2003 was perceived in U.S. policymaking circles as leading to a swift, costless, and certain victory. Iraqi nuclear acquisition, on the contrary, was seen by U.S. decisionmakers as potentially leading to nuclear attacks against one or more U.S. cities. Comparing the two outcomes, U.S. decisionmakers decided that preventive war was a better course than allowing Iraqi nuclear acquisition.

Our theory therefore offers a simple explanation for the lower rate of proliferation and the higher likelihood of preventive war in the post-Cold War. During the Cold War, nuclear proliferation had little effect on the overall balance of power between the two superpowers.
At the same time, any war between them would have extremely high costs. Thus, neither superpower had the ability credibly to threaten a member of the other’s bloc with a preventive counterproliferation strike. Such a strike would invite a retaliatory escalation, resulting in general war. Nuclear proliferation thus continued apace while peace prevailed. In the post-Cold War, however, the overall balance of power is skewed towards the the United States (Wohlforth, 1999), which can therefore launch preventive wars at a relatively lower cost. At the same time, nuclear acquisition would significantly improve a state’s position vis-à-vis the United States. Thus, the United States should be concerned with nuclear proliferation, while recognizing that the credibility of its threat to strike preventively ensures the general success of its counterproliferation policy.

Counterproliferation, by involving an (implicit or explicit) threat of military action in order to prevent the spread of nuclear weapons, is essentially a problem of deterrence. Throughout the Cold War, deterrence was one of the most influential bodies of IR literature and arguably the cornerstone of peace. Since the fall of the Soviet Union, however, deterrence has lost much of its appeal, both in theory and in practice. As one of the foremost experts on the topic laments, “interest in deterrence collapsed with the Cold War itself” (Freedman, 2005, 789). This waning of interest results from the unparalleled power the United States enjoys, which enables it to deter state-led attacks on itself and its main allies with relative ease. The U.S.’s security concerns have therefore been replaced with a more diffuse set of problems, such as nuclear proliferation and terrorism – problems that are prima facie beyond the purview of deterrence (Smith, 2003, 155).

In our view, however, the deterrence conceptual apparatus is of great use in analyzing nuclear proliferation. By modeling counterproliferation as a deterrence problem, we can examine the strategic interaction between, on one side, the state that is considering the development of nuclear weapons and, on the other, that which is threatening it with negative consequences should it develop them. This interaction – which takes place before nuclear acquisition and, therefore, before the balance of power shifts – conditions both the likelihood of nuclear acquisition and that of preventive war.

Furthermore, an analysis of nuclear proliferation through this prism enables us to focus on an aspect of deterrence that remained neglected during the Cold War – assurances. As

2The deterrence literature is vast. For a good summary, see Lupovici (2010, 706-710).
Schelling (1966, 74-75) puts it in his classic *Arms and Influence*, “any coercive threat requires corresponding assurances: the object of a threat is to give somebody a choice. To say, ‘One more step and I shoot,’ can be a deterrent threat only if accompanied by the implicit assurance, ‘And if you stop I won’t.’” Yet, reflecting the relative importance of threats and assurances in extant treatments of deterrence, Schelling devotes sixty pages of the book to a discussion of how to make threats credible and then writes one single page about assurances. This relative negligence of the problem of assurances can be explained in part with the great costs of military conflict between the two superpowers – the very reason for the concern on the credibility of threats. Balanced power, as it were, provides its own assurance. In addition, U.S. policy was generally seen as a status quo oriented, limiting the perceived need for explicit assurances (Brodie, 1959).³

Since the end of the Cold War, U.S. power is unmatched and the cost of a possible war is comparatively lower (Wohlforth, 1999). Coincidentally, at least during the 2001-2008 period, the U.S. has abandoned its professed position as a status quo power and embraced an outspokenly revisionist grand strategy, which resulted in two wars: Afghanistan and Iraq. These changes necessitate a reevaluation of the role of assurances in deterrence. Our theory places the problem of assurances squarely at the center of counterproliferation efforts.

While our theory applies to any investment in military power, we restrict our argument to investments in nuclear acquisition for two reasons. First, nuclear acquisition is perhaps the greatest single discrete shift in relative power that can be achieved through a process of investment in military acquisition. As Levy (2008, 7) puts it, “The crossing of the nuclear threshold is the most consequential manifestation of a step-level power shift.” Therefore, we should be particularly likely to find our theory at work in cases of nuclear counterproliferation. Second, nuclear weapons have such destructive capability that the problem of nuclear proliferation has acquired a status in policy and scholarship independent of other types of arms proliferation and military investments.

This interest in countering proliferation has increased since the end of the Cold War, in part because of a consensus – in our view, wrongheaded – that “nuclear proliferation and its effect on U.S. national security interests constitutes the gravest threat facing the United States, that it is worse than ever before, and that new, more effective policies are needed to confront the problem” (Gavin, 2010, 7). Among the causes of this nuclear alarmism is the end of the

³For an opposing view, see Layne (2006).
Cold War. Frankel (1993, 37) writes that “nuclear arms proliferation will likely intensify” in the post-Cold War. Potter and Mukhatzhanova (2010a, 78) conclude that “[t]oday the proliferation metaphors of choice are ‘nuclear cascade’ and ‘tipping point,’ but the implication is the same – we are on the cusp of rapid, large-scale nuclear weapons spread.” We beg to differ.

Given its policy relevance, nuclear proliferation has been the subject of a growing literature. This literature has attempted to address the perceived shortcomings of the security model, which suggests that countries acquire nuclear weapons for security reasons, thus overpredicting proliferation (Sagan, 1996-97). Beyond country-specific aspects, proliferation scholarship has focused on other factors, such as the domestic determinants of nuclear proliferation, based on the political preferences of ruling coalitions (Solingen, 2007) or leaders (Hymans, 2006).

While we value these contributions, we believe we still need a proper understanding of the effect of the balance of power on the likelihood of successful and peaceful counterproliferation efforts. By attempting to provide one, this paper speaks directly to a large literature on systemic effects of the balance of (military) power on international conflict (Levy, 2002). Structural realists have long argued that peace depends on the presence of a balance of power (Waltz, 1979; Mearsheimer, 2001). Hegemonic realists have made the opposite point – that peace depends on the absence of a balance of power, which occurs only during power shifts, and are prone to generate wars (Gilpin, 1981; Organski and Kugler, 1984). The question of whether investments that create – or disrupt – a balance of power can be deterred is therefore of paramount importance.

So is the question of whether such investments can prompt preventive wars (Powell, 1996a,b, 2006). The concept of preventive war has been the object of great scrutiny, particularly in the aftermath of the invasion of Iraq in 2003. Yet the conditions under which preventive motivations for war lead to conflict have never been clearly stated. More particularly, there are very few

\[\text{Recent important pieces on the topic include Paul (2000); Singh and Way (2004); Hymans (2006); Solingen (2007); Jo and Gartzke (2007); Fuhrmann (2009a,b); Kroenig (2009); Montgomery and Sagan (2009); Potter and Mukhatzhanova (2010b).}\]

\[\text{For an attempt to correct the security model, see Paul (2000), who shows how regional concerns may trump the drive to maximize power, leading states to act prudently by forfeiting nuclear weapons.}\]

\[\text{On the historical importance of preventive/preemptive motives in the American context, see Gaddis (2004). For doubts on the importance of the preventive motive, see Lemke (2003);}\]
studies of the causes of preventive strikes against WMD-producing facilities. Feaver and Niou (1996), for example, argue that a preventive attack on the Soviet Union was not undertaken because of its prohibitively high cost. Yet we argue that the cost of a preventive war only tells part of the story. The crucial relation is that between the costs of preventive war and the size of the power shift it is meant to avoid – a cost-benefit calculation in which leaders engage when considering a preventive strike (see section 4). Moreover, by relating the cost of war with the magnitude of the power shift produced by nuclear acquisition, our theory captures the effect of the overall balance of power on the odds of preventive strikes. We argue that incentives to launch such strikes are greater in the post-Cold War, a finding that is corroborated by Fuhrmann and Kreps (2010).

On this point, note that in his study of democracy and preventive war, Schweller (1992, 238) argues that “only nondemocratic regimes wage preventive wars against rising opponents”. But, in a caveat that is rarely acknowledged (Levy, 2008, 9), Schweller writes that his argument about democratic pacifism “concerns only power shifts between states of roughly equal strength; it is not relevant to all power shifts, for example, the case of the relative decline of a large state vis-à-vis a much smaller state” (Schweller, 1992, 248, emphasis added). Our theory dovetails nicely with Schweller’s point, specifying the conditions under which preventive war is rational. At the same time, we specify those under which appeasement makes sense. When the effect of nuclear acquisition on the balance of military power is smaller than the costs of a preventive war, “appeasement” (i.e., peaceful acceptance of another state’s investment in nuclear weapons) Reiter (2006).

For recent experimental evidence on popular support for preventive strikes against nuclear weapons programs, see Tomz and Weeks (2010).

By contrast, their result depends on the risk-preferences of the potential proliferator and the commitment to nonproliferation by the respondent – variables that are difficult to observe and predict.

Small numbers make their finding statistically insignificant, though. For example, the U.S. considered 12 strikes (enemy-year) and attacked in 3 out of 9 of these episodes during the Cold War and 2 out of 3 of these episodes after the Cold War. The results could even be stronger with a less stringent definition of the Cold War, which in their coding, starts after the collapse of the Soviet Union (i.e. in 1992). Note that one of these ‘Cold War’ strikes was against Iraq in 1991, when the country had already lost the Soviet Union as a patron (see section 4 below).
is the rational policy response (Powell, 1996b; Rock, 2000; Treisman, 2004).

Finally, we contribute to the literature on rationalist explanations for war (Fearon, 1995; Powell, 1999). In the last fifteen years, the reasons structural theorists have presented as causes for war – anarchy, shifts in the balance of power, uncertainty about intentions, etc. – have been shown to provide an insufficient account. Since Fearon (1995), informational and commitment problems have been established as the mechanisms through which war occurs. In his seminal paper, Fearon formalizes the argument that a declining state may launch a war to prevent an adverse shift in the balance of power. In his argument, however, shifts in the balance happen exogenously. Very few papers have attempted to endogenize such shifts in the balance of power (Fearon, 1996; Chadeaux, 2009; Powell, 2010; Bas and Coe, 2010) or considered the incentives to acquire military capacity (Baliga and Sjostrom, 2008; Meirowitz and Sartori, 2008; Jackson and Morelli, 2009; Bas and Coe, 2010; Fearon, 2010). None of these papers has modeled the acquisition of military power as an investment with delayed returns. By modeling the strategic interaction as a deterrence problem, we show that under complete information peace always prevails. Large shifts in the balance of power make the threats of war by the deterrer credible and, as a result, enforce peace. Only if the deterrer is imperfectly informed about the target’s action can war occur. In short, when shifts in the balance of power are endogenized, commitment problems alone cannot generate war.

3 The Model

3.1 Strategies and Payoffs

This is a game between two states, $D$ (the ‘deterrer’) and $T$ (the ‘target’) who divide a pie of size 1 in each of two periods, 1 and 2. Initially, $T$ has no nuclear weapons and decides whether to acquire some through military investment $m \in \{0, 1\}$, where $m = 1$ means that the investment takes place, $m = 0$ otherwise. Let the cost of investment be $k > 0$.

$T$’s military investment decision is not observable to $D$ in period 1. Formally, $D$ receives a signal $s_1$ about $m$ in period 1, which takes one of two values, 0 or 1. If $T$ does not arm ($m = 0$), signal $s_1$ takes a value of 0. If $T$ arms ($m = 1$), it takes a value of 1 with probability $p_s$ and 0 with probability $1 - p_s$. Intuitively, a signal of 1 represents the discovery of hard evidence of investment. This evidence proves that $T$ invested, but it is not necessarily discovered if $T$
invests. We consider three cases: whether the signal is perfectly informative \((p_s = 1)\), perfectly uninformative \((p_s = 0)\) or partially informative \((p_s \in (0, 1))\). For simplicity, we assume that \(T\)’s investment decision is revealed in period 2, when the investment comes to fruition (i.e. signal \(s_2\) is perfectly informative, or \(s_2 = m\)).

In period 1, after the investment decision is taken and the signal is sent, countries divide a pie. First, \(D\) offers a share \(z_1\) of the pie to \(T\), keeping \(1 - z_1\) for herself, or unilaterally declares war. If \(T\) accepts \(D\)’s offer, it is implemented. If \(T\) rejects \(D\)’s offer, war ensues and country \(i\) gets a payoff \(w_i (A_t) \geq 0\) which depends on the armament status \(A_t\) of country \(T\) at time \(t\) \((A_t \in \{0, 1\})\), where \(T\) is armed if and only if \(A_t = 1\). We assume that \(T\) starts the game unarmed and that the investment has delayed returns. Thus, \(T\) always remains unarmed in period 1. If \(T\) invests in period 1 and peace prevails, she becomes armed in period 2. If war occurs in period 1, then \(T\) remains unarmed in period 2.\(^{10}\) In period 2, the game follows the same timing as in period 1, except that \(T\) does not have the option of investing.\(^{11}\)

We assume that war is costly, so that, for any \(A_t \in \{0, 1\}\),

\[
w_T (A_t) + w_D (A_t) < 1
\]  

We call \(1 - w_T (0) - w_D (0)\) the cost of a preventive war.

Countries discount future payoffs by a factor of \(\delta\). We restrict our attention to productive investments, which satisfy

\[
k < \delta w_T (1) - (1 + \delta) w_T (0)
\]

or the fact that the cost of investment \((k)\) is lower than the effect of investment on the balance of power \((\delta w_T (1) - (1 + \delta) w_T (0))\).\(^{12}\)

\(^{10}\)It is common to assume that war ends a game. Such an assumption would produce the same results, but we prefer our current set-up, as it captures the extreme case where any preventive war succeeds with probability 1 in destroying the target’s nuclear program. We plan to consider intermediate cases in future work.

\(^{11}\)We could let \(T\) invest in period 2, but \(T\) would never choose to do so, since investment is costly, takes one period to come to fruition, and period 2 is the last period of the game.

\(^{12}\)We could call \(\delta (w_T (1) - w_T (0))\) the effect of the investment on the balance of power. This would not affect the results. Comparative statics would be more elegant, but the description of the regions of the parameter space would be more cumbersome.
Summing up, the timing of the game is as follows:

### 3.2 Timing

**First Period**

1. $T$ makes her military investment decision ($m$)
2. Signal $s_1$ about $T$’s military investment decision ($m$) is sent
3. $D$ proposes a division of the pie, indexed by $z_1$, or unilaterally declares war.
4. $T$ accepts/rejects $D$’s offer.

**Second Period**

1. Signal $s_2$ about $T$’s military investment decision ($m$) is sent
2. $D$ proposes a division of the pie, indexed by $z_2$, or unilaterally declares war.
3. $T$ accepts/rejects $D$’s offer.

### 3.3 Solution Concept

This is a dynamic game of incomplete information. We solve for Perfect Bayesian Equilibria. This requires that at each information set, play is sequentially rational given beliefs and that beliefs are updated using Bayes’ rule whenever possible (Fudenberg and Tirole, 1991, 325-326).\(^\text{13}\)

### 3.4 Solving the Game

First, it is straightforward to show the following result:

**Proposition 1** In period 2, there is always peace, where $D$ offers $z_2^* = w_T(A_2)$ and $T$ accepts if and only if $z_2 \geq w_T(A_2)$.

**Proof.** $T$ accepts $z_2$ if and only if $z_2 \geq w_T(A_2)$. $D$ prefers peace if and only if $1 - z_2 \geq w_D(A_2)$. Since war is costly (condition 1), $D$ prefers to offer $z_2^* = w_T(A_2)$ to declaring war. ■

\(^\text{13}\)If there is an equilibrium with no investment, beliefs are not pinned down by Bayes’ rule after a signal of $s_1 = 1$. We will assume that, after such a signal, $D$ believes that $T$ invested with probability 1, which is the only decision that can generate such a signal.
This proposition shows that peace prevails in period 2, since it is the end of the game and no information problem persists. In equilibrium, $T$ receives a more generous offer in period 2 if it is armed, since it would fare better in a conflict with $D$.

We now move up to period 1. Consider first the benchmark case where signal $s_1$ is perfectly informative ($p_s = 1$). Then we can show:

**Proposition 2** In equilibrium, peace prevails. Moreover, deterrence succeeds if and only if the effect of investment on the balance of power is greater than the cost of a preventive war.

**Proof.** See the appendix.

The intuition for this result is as follows. By failing to respond to $T$'s investment with a preventive war, $D$ must make larger concessions to $T$ in period 2 (see proposition 1). If the effect of investment on the balance of power is larger than the cost of a preventive war, $D$ prefers to respond to an investment by $T$ with war. Anticipating this reaction, $T$ does not invest. Investment means paying a cost to shift the balance of power in her favor, but fighting before the shift in the balance of power can occur. If the effect of the investment on the balance of power is smaller than the cost of a preventive war, however, then $D$ prefers peace as a response to $T$’s investment. Since the investment is productive (condition 2), $T$ strictly prefers to invest.

There are a few interesting points that stand out from this analysis. First, deterrence succeeds only if the effect of investment on the balance of power is larger than the cost of a preventive war. The model thus sheds light on the concern of the classic literature on deterrence in the Cold War. In this period, when faced with a possible conflict with another superpower, the cost of war was so high, relative to any possible shift in the balance of power, that the credibility of U.S. threats was low. As a result, deterrence could succeed only if the U. S. could not revisit its decision to fight a war (tying its own hands or taking actions that ‘lead something to chance’). In the unipolar world of the post-Cold War period, nuclear proliferation may have a large effect on the balance of power, relative to the cost of a preventive war. Thus deterrence is more likely to be successful, generating a relatively low rate of proliferation.

Second, when armament is modeled as an investment, it is easy to rationalize why $D$ would sanction an arming state with harsher terms. Once the investment is realized, $T$ can extract greater rents in period 2. Therefore, it is the arming state who has the most to gain from peace. To deter $T$ from arming, $D$ must reward it with more generous terms if it decides not to arm,
or ‘sanction’ it for arming. By contrast, if armament instantly shifted the balance of power, then $D$ would be forced to offer more generous terms to avoid conflict.

Third, by modeling the change in the balance of power as the result of a decision by $T$, we show that the anticipation of large shifts in the balance of power does not produce war. This stands in contrast with the seminal work of Fearon (1995). In that framework, a declining state decides to fight a war to prevent the (exogenous) shift in the balance of power. In our set-up, the shift in the balance of power is the result of an armament decision by a state. Since $D$ would fight a war to prevent the adverse shift in the balance of power, $T$ never gains from investing in arms, if that decision is perfectly detected by $D$.

In reality, investment in arms are not perfectly observable to outside actors. We now consider the benchmark case where the signal about $T$’s armament decision in the first period is completely uninformative ($p_s = 0$). Then we can show

**Proposition 3** In equilibrium,

(i) If the effect of investment on the balance of power is lower than the cost of a preventive war, peace prevails and deterrence fails.

(ii) If the effect of investment on the balance of power is greater than the cost of a preventive war, $T$ arms with probability $q^* = \frac{1 - w_T(0) - w_D(0)}{\delta(w_T(1) - w_T(0))}$ and war happens with probability $1 - r^* = 1 - \frac{k}{\delta[w_T(1) - w_T(0)]}$.

**Proof.** See the appendix.

First, this proposition builds on the fact that, if the effect of investment on the balance of power is lower than the cost of a preventive war, then $D$ always prefers peace. Even if $D$ knew that $T$ was arming, it would still prefer not to wage a war. Thus, the informativeness of the signal does not change the conclusion: under these circumstances, peace prevails and, since the investment is productive, $T$ makes the investment.

Second, the proposition shows that, if the effect of investment on the balance of power is greater than the cost of preventive war, then the equilibrium is in mixed strategies. Indeed, assume that $T$ arms with probability one. Then $D$’s best response is to wage war, but $T$ would then prefer not to invest in arms, as investing is costly and war happens before the balance of power is changed. Likewise, assume that $T$ does not arm. Then $D$’s best response is to reward $T$ with a generous peaceful offer (of $z_1 = w_T(0)$), but $T$ would then prefer to invest in arms.
The deviation would go unnoticed, $T$ would still avoid ‘sanctions’ in period 1 and benefit from a favorable change in the balance of power in period 2. Thus the equilibrium has $T$ mixing between investment and no investment and $D$ mixing between war and a generous offer. In this case, deterrence fails and war occurs because $D$ cannot condition her response on $T$’s decision, which she does not observe. We can also add:

**Corollary 1** Everything else being equal,

1. The probability of war is increasing in the effect of investment on the balance of power
2. The probability of successful deterrence is increasing in the effect of armament on the balance of power
3. Wars are more likely to be waged against an unarming $T$, the greater is the effect of investment on the balance of power

**Proof.** See the appendix. ■

The intuition for these results is as follows. It is clear that the probability of war remains constant (at zero) when the effect of investment on the balance of power is smaller than the cost of preventive war, and that it increases (to a positive value) when it becomes greater than the cost of preventive war. When the effect of investment on the balance of power is greater than the cost of preventive war, countries play a mixed strategy equilibrium. $D$’s strategy leaves $T$ indifferent between arming and not arming. The greater is the effect of investment on the balance of power, the greater is the benefit of arming, everything else being equal, as it leads to a larger change in the peaceful terms for $T$ in period 2. To ensure $T$’s indifference between armament and no armament, $D$ must declare war with a greater probability, which reduces the benefit of armament ($T$ pays a cost but must endure war before the shift in the balance of power is realized). This proves point (i).

By the same logic, now applied to $T$’s strategy, we prove point (ii). The greater is the effect of armament on the balance of power, the greater is the benefit of war for $D$, everything else being equal, as it prevents a greater fall in peaceful terms in period 2. To ensure $D$’s indifference between war and making a generous peaceful offer, $T$ must be less likely to arm, which reduces the benefit of war. This argument also proves point (iii). Indeed, since $D$ has no information about $T$’s decision and generates war with some fixed probability, then the probability that $T$ is unarmed, conditional on war, is simply the probability of successful deterrence, which we have shown to be increasing in the effect of investment on the balance of power.
Of course, countries will in reality have some information about the investment decision of their enemies. We now consider the more realistic case where the signal about T’s armament decision in the first period is partially informative \((p_s \in (0, 1))\). We get the following:

**Proposition 4** In equilibrium,

(i) If the effect of investment on the balance of power is lower than the cost of a preventive war, peace prevails and deterrence fails.

(ii) If the effect of investment on the balance of power is greater than the cost of a preventive war, then there are two cases.

(ii.1) If the signal of T’s action is sufficiently informative, i.e. if

\[
    p_s \geq 1 - \frac{k}{\delta [w_T(1) - w_T(0)]}
\]

then T does not arm (deterrence succeeds). If D receives signal \(s_1 = 1\), it declares war. If it receives signal \(s_1 = 0\), it offers \(z_1 = w_T(0)\), which is accepted by T along the equilibrium path.

(ii.2) If the signal of T’s action is not sufficiently informative (condition 3 does not hold), then T invests with probability

\[
    q^* = \frac{1}{p_s + (1 - p_s) \frac{\delta [w_T(1) - w_T(0)]}{1 - w_T(0) - w_D(0)}}
\]

If D receives signal \(s_1 = 1\), it declares war. Otherwise, D declares war with probability

\[
    1 - r^* = 1 - \frac{k}{(1 - p_s) \delta [w_T(1) - w_T(0)]}
\]

and offers \(z_1 = w_T(0)\) with probability \(r^*\), which is accepted by T along the equilibrium path.

**Proof.** See the appendix.

First, this proposition confirms that the outcome of the game, if the effect of investment on the balance of power is smaller than the cost of preventive war, is independent of the informativeness of the signal.

Second, if the effect of investment is greater than the cost of preventive war, then the outcome does depend on the informativeness of the signal. If it is sufficiently high (condition 3 holds), D successfully deters country A. T understands that she is likely to be detected, if she invests
in arms, with $D$ declaring war before the balance of power is affected. Therefore, she prefers not to invest in arms. If the signal is not sufficiently informative, then $T$ is reasonably confident that she can invest without being detected. The unique equilibrium is in mixed strategies, for the same logic outlined above. We can also add the following:

**Corollary 2** If the signal is sufficiently informative (condition 3 holds), then peace prevails. Moreover, deterrence succeeds if and only if the effect of investment on the balance of power is greater than the cost of a preventive war. If the signal is not sufficiently informative (condition 3 does not hold), then everything else being equal,

(i) The probability of war is increasing in the effect of investment on the balance of power

(ii) The probability of successful deterrence is increasing in the effect of armament on the balance of power

(iii) Wars are more likely to be waged against an unarming $T$, the greater is the effect of investment on the balance of power

**Proof.** See the appendix.

These conclusions follow from the same logic as we outlined for corollary 1. They form the main predictions of the model, which we now explore in the empirical record.

### 4 Evidence

In this section, we use two case studies – the Soviet nuclear acquisition in 1949 and the invasion of Iraq in 2003 – to display the mechanisms developed in our theory about how (i) the effect of nuclear acquisition on the balance of power, (ii) the cost of preventive war, and (iii) the quality of the signal about the decision to proliferate interact to condition the probability of successful counterproliferation and that of preventive war.

#### 4.1 Soviet Nuclear Acquisition

On August 29, 1949, the Soviet Union ended a four-year U.S. monopoly over nuclear weapons by testing its own nuclear device. The Soviet nuclear program, launched in 1942, had been known to the United States throughout the nuclear-monopoly period. Still, the United States did not launch a preventive strike in order to stop the Soviet nuclear program. Why did the only state in history to possess a nuclear monopoly fail to use this advantage to prevent its end?
The conventional wisdom on why a U.S.-launched preventive attack against the Soviet nuclear program never materialized is centered around two reasons.\footnote{Quester (2000), the most thorough investigation of the decision not to use the U.S.’s nuclear monopoly to prevent the Soviets from ending it, lays out more than twenty practical/procedural and moral factors that may have played a role in the decision-making, but does not conclude which effectively did.}

First, the information possessed by the United States about the state of the Soviet program was poor (Richelson, 2006; Goodman, 2007). By 1945, U.S. intelligence pointed to a date for a Soviet nuclear test anywhere between three and twenty years down the road. Eventually, a consensus around a five-year estimate put forth by the scientific community emerged. This five-year figure, however, remained unchanged. Consequently, at no point did U.S. leaders think that the Soviets were close to acquiring the bomb (Gordin, 2009, 66).\footnote{On July 1, 1949, less than three months before the Soviet test, Admiral R.H. Hillenkoeter, Director of the CIA, predicted that “the earliest date by which it is remotely possible that the U.S.S.R. may have completed its first atomic bomb is mid-1950, but the most probable date is believed to be mid-1953.” Quoted in Holloway (1994, 220). An estimate published after the Soviet test – but before U.S. detection – reasserted these predictions (CIA, 1994, 319).} Therefore, the argument goes, preventive war was not considered seriously because the Truman administration never estimated Soviet acquisition to be imminent. As Gordin (2009, 87) writes, “[t]he first immediate effect of a lengthy estimate was to discourage a preemptive strike against the Soviet Union.”

But a dovish stance does not necessarily follow from the presumed length of the window of opportunity until Soviet acquisition. For example, General Leslie Groves, the top military commander in charge of nuclear weapons, estimated the duration of the American atomic monopoly at more than twenty years, and yet strongly advocated for preventive war. As early as January 1946, he wrote to Congress that either the Soviets accepted a global nuclear disarmament treaty (which they wouldn’t) or the United States “should consider a preventive attack against Soviet atomic research facilities to guarantee American supremacy” (quoted in Buhite and Hamel (1990, 374)). More generally, U.S. top decisionmakers knew the estimates were mere guesses. David Lilienthal, the chairman of the Atomic Energy Commission (henceforth AEC, which controlled the U.S. arsenal in the early post-war years), noted that the intelligence estimates were “five percent information and ninety-five percent construction ... [based on sources] so poor as
to be actually merely arbitrary assumptions” (quoted in Goodman (2007, 28)). These doubts prompted the military to prepare preventive war plans as early as October 1945.

The second reason usually invoked to explain the absence of a U.S. preventive strike is morality. In a 1948 meeting with members of the AEC, Truman opposed the military’s request for control of the nuclear arsenal, arguing that nuclear weapons’ destructive power places them in a category of their own and adding “It is a terrible thing to order the use of something like that ... that is so terribly destructive, destructive beyond anything we have ever had” (quoted in Rhodes (1995, 327)). After the Soviet test, Truman justified the absence of a preventive strike by saying: “Such a war is the weapon of dictators, not of free democratic countries like the United States” (quoted in Sagan (1994, 78)). In short, moral reasons seem to have precluded a preventive attack.

Yet many in American society – including political elites – had no moral qualms about endorsing a preventive strike. Indeed, Trachtenberg (2007, 4-5) writes that “when you look at the evidence from this period, you find preventive war arguments all over the place. ... [P]reventive war thinking was surprisingly widespread in the early nuclear age.” Moral arguments, therefore, cut both ways, and many invoked the morality of preventing the Soviets from acquiring the means to incinerate the West.

In our view, the morality of a preventive war against the Soviets appeared questionable because of the magnitude it entailed. Put succinctly, initial U.S. war plans admitted that a war with the Soviet Union would be long and costly, first forcing the U.S. out of Europe. Later war plans were more optimistic about the prospects of victory, but only because the weakness of American conventional forces was to be compensated by a massive air-atomic campaign. In either set of circumstances, the costs of war exacerbated moral concern about prevention.

While each of these two arguments – time window and morality – may have mattered, we argue that neither, in and of themselves, offers a convincing explanation of the U.S. decision not to strike the Soviet Union preventively. Our own explanation is that Truman understood – as did Stalin – that, although Soviet nuclear acquisition would have a significant adverse impact

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16 Quester (2000, chapter 3) devotes an entire chapter to what he calls “outright advocates” of the preventive war option, listing prominent politicians, scientists, and military leaders who advocated for a strike. See also: Buhite and Hamel (1990, 367) and Williamson Jr. and Rearden (1993, 140).
on U.S. power vis-à-vis the Soviet Union, the costs of war (even accounting for the U.S. nuclear monopoly) were too high to allow for a preventive U.S. strike against the Soviet program.

The reasons were the following. To begin with, the quality of U.S. intelligence on the location of Soviet nuclear facilities was poor. U.S. intelligence in the late 1940s (in the pre-satellite, pre-surveillance airplanes era) relied mostly on data obtained from German prisoners of war and maps from the German invasion of Russia in 1941, before the Soviet program took off.\textsuperscript{17} This intelligence gap made it impossible to launch a surgical strike. As a consequence, the target-set for any preventive strike would have to be very large; in practice, indistinguishable from an attempt to destroy the entire Soviet state.

Such an exacting military goal, however, was well beyond the reach of the United States. Indeed, the U.S. nuclear arsenal was remarkably small throughout the monopoly period. As David Rosenberg notes, in the early post-war era

the most critical determinant in strategic and operational planning was capability.

From 1945 through 1948, the vaunted era of American nuclear monopoly, the nation’s stockpile and delivery capability were extremely limited. There were only two weapons in the stockpile at the end of 1945, nine in July 1946, thirteen in July 1947, and fifty in July 1948. None of these weapons was assembled (Rosenberg, 1983, 14).

Although the Berlin blockade, starting in late June 1948, led to an increase in the production of nuclear weapons, by the time the Soviets tested their nuclear device in September 1949, the United States arsenal consisted in less than 200 bombs.\textsuperscript{18} By mid-1950, one year after the Soviet nuclear breakthrough, the U.S. arsenal totaled less than 300 bombs (Holloway, 1994, 230).

This small number of nuclear devices, when combined with a shortage of modified bombers able to drop them and of crews trained to load the bombs and fly the airplanes (Rosenberg, 1982b, 29), left the United States very far from the military requirements for destroying a

\textsuperscript{17}On the difficulty of U.S. intelligence gathering on the Soviet nuclear program, see Gordin (2009, 80-85). The Soviets proved extremely apt at hiding their nuclear facilities, in one case under a lake – see Zaloga (1993, 50, 62, 68) and Rhodes (1995, 287).

\textsuperscript{18}The most accurate estimate available puts the number at 169 – see Norris and Arkin (1983b, 48) and Norris and Arkin (1983a, 58-59). Their figures supersede the previous (inflated) estimates in Rosenberg (1982b, 25-30). On the limiting effect of the small stockpile on U.S. war plans, see Buhite and Hamel (1990, 383) and Williamson Jr. and Rearden (1993, 107-111).
country as vast as the Soviet Union, which, according to a 1945 study by the air force, were placed at 466 bombs (Rhodes, 1995, 226). This means that, as Buhite and Hamel (1990, 383) write, U.S. “war plans consistently demanded more bombs than existed in the U.S. arsenals well into the 1950s.” The U.S. nuclear monopoly was, in essence, a nominal monopoly. Any preventive strike would therefore need to rely overwhelmingly on conventional forces, entailing considerable casualties and a protracted war. In sum, the U.S. administration had no clear line of sight to a quick military victory in a preventive strike against a pre-nuclear Soviet Union.

Without such a quick-victory in sight, however, a preventive strike posed a third problem – Soviet retaliation. U.S. war plans were extremely pessimistic in this respect. After the quick post-World War II U.S. demobilization, the balance of conventional forces, especially in Europe, heavily favored the Soviets. A November 1945 JIC/JCS report argued that, in case of a war in Europe, “the Soviets would enjoy a great preponderance in numbers of men against the United States or even against the United States, Great Britain and France” (Holloway, 1994, 231). By mid-1946, the staff in charge of drafting the (failed) Baruch nuclear disarmament plan noted that the “U.S. has gone so far in its demobilization of the Army and Navy that if we were to stop making bombs we would be almost defenseless and would certainly have only a modicum of military power with which to stand up to the U.S.S.R.” (Gordin, 2009, 54).

In December 1947, Secretary of Defense James Forrestal considered the “predominance of Russian land power in Europe and Asia” to be one of the “outstanding military factors in the world” at the time (Rhodes, 1995, 313). As Gaddis (1987, 109) notes, “one Pentagon estimate credited [the Soviet Union] with sufficient strength to overrun most of continental Europe, Turkey, Iran,

As Rhodes (1995) notes, some in the armed forces thought these requirements to be too high and underestimate the destructive potential of nuclear weapons, but the basic point is that the arsenal of the time was much below what was needed to deal a decisive blow to the Soviet Union was consensual.

Along similar lines, Rhodes (1995, 301) writes: “By 1947, with fewer than 1.5 million men under arms, the United States had made the atomic bomb its first line of defense (however thin the line) as it began to mount a broad, worldwide challenge to what it perceived to be Soviet expansionism.” For an estimate of the balance of forces in the European that was less unfavorable to the U.S., see Evangelista (1982-83). The key point is that U.S. decisionmakers and the general public at the time took for granted the Soviet ability to overrun Western Europe (Evangelista, 1982-83, 110).
Afghanistan, Manchuria, Korea, and North China.”

Explicitly addressing the issue of preventive war with the Soviet Union, the Harmon Committee report, published in May 1949, concluded that even if the United States were able to destroy seventy Soviet cities as planned, this would not “bring about the capitulation, destroy the roots of Communism, or critically weaken the power of the Soviet leadership to dominate the people.” In a massive understatement, the report mentioned that such an attack would “produce certain psychological and retaliatory reactions detrimental to the achievement of Allied war objectives and its destructive effects will complicate post-hostilities problems.” Furthermore, “the capability of Soviet armed forces to advance rapidly into selected areas of Western Europe, the Middle East, and the Far East would not be seriously impaired.” In short, certain Soviet retaliation against a U.S. preventive strike was likely to lose to massive manpower, materiel, and territorial losses to the United States.

To conclude, in the absence of intelligence that enabled the construction of a target-set for a surgical strike against Soviet nuclear facilities, a preventive strike required a nuclear arsenal capable of crippling the Soviet Union. Since the U.S. arsenal was far from possessing this capability, a preventive strike would require a massive conventional attack. Alas, such an attack was likely to lead to retaliation in three areas – Western Europe, East Asia, and the Middle East – where the balance of power strongly favored the Soviets. Retaliation was thus likely to result in great territorial gains for the Soviet Union. A combination of poor intelligence, the small size of the U.S. nuclear arsenal, and the balance of conventional forces meant a preventive strike would involve costs beyond the point at which it no longer made sense. While morality may have played a role, as Buhite and Hamel (1990, 382-383) conclude, “[l]imited American capabilities were probably a greater element behind the decision not to engage in preventive war.” In sum, preventive war against the Soviet Union in the period of U.S. nuclear monopoly was estimated to lead precisely to the outcome U.S. policy feared might result from Soviet nuclear acquisition – Soviet territorial expansion in areas of crucial interest. A preventive strike would therefore be self-defeating (see Borowski (1982, 125-128), Nitze, Rearden and Smith (1989, 109-110), and Williamson Jr. and Rearden (1993, 140-141)).

21 All quotes of the Harmon Report come from Rosenberg (1982a).
4.2 The U.S.-led Invasion of Iraq

On March 20, 2003, a U.S.-led coalition invaded Iraq, quickly defeating Iraqi forces and deposing Saddam Hussein’s regime. Baghdad fell a mere twenty one days after the invasion was launched and the major-operations phase of the war ended six days later.

In the past, Iraq had possessed impressive military forces, supplied mostly by the Soviet Union. But as the Cold War ended, Saddam’s regime found itself in a weaker geostrategic position. Already in 1991, during the Gulf War, Iraqi forces had been decisively defeated and expelled from Kuwait by a broader U.S.-led coalition (Gordon and Trainor, 1995). Significantly, Iraq lost much of its military materiel in that conflict.22 The vulnerability created by the Soviet collapse was duly noted in Baghdad. Tariq Aziz, Saddam’s foreign minister, lamented after the 1991 defeat, “[w]e don’t have a patron anymore. ... If we still had the Soviets as our patron, none of this would have happened” (Friedman and Tyler, 2006). Severely weakened by defeat in the Gulf War, Saddam’s armed forces were further crippled by the stringent sanctions imposed on the country as a result of that conflict. By 2003, Iraq’s geostrategic position was at its weakest, with no great-power sponsors and a poorly trained and equipped military. By then, the balance of power clearly favored the United States.

The swift victory obtained by the U.S.-led coalition in the 2003 invasion hence reflects the striking imbalance of power at the outset of the war. Although fighting a defensive war in well-known terrain, against an expeditionary force deployed across the globe from its home countries, they lost all engagements with coalition forces and ended up suffering 9,200 fatalities – or more than fifty times the 172 lives lost by coalition forces.23 In sum, in the post-Cold War era, the United States’ ability to depose Saddam was never in doubt.

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22 On February 22, 1991, well into the opening air campaign against Iraqi forces but before the ground war started, Saddam accepted a modified Soviet plan to withdraw from Kuwait in 21 days. The U.S. administration, however, rejected this offer, demanding a seven-day withdrawal, with the purpose of forcing Saddam to leave behind his materiel, in particular armored vehicles. The ground war resulted from Saddam’s rejection of this demand, which would leave him with little more power than a military defeat. Most Iraqi materiel deployed in Kuwait ended up being destroyed, however (Pape, 1996).

23 A U.S. Army study attributes the outcome of the war to “a synergistic interaction between advanced coalition technology and a major skill differential” (Biddle et al., 2004, v). The performance of Iraqi forces was plagued by constant strategic and tactical errors. Worse, were
During the crisis that led to the invasion, the U.S. government’s *casus belli* rested on suspicion that Saddam Hussein was developing WMDs – including nuclear weapons – and thus presented an imminent threat (Freedman, 2004). Granted, a multiplicity of arguments was introduced to justify the invasion, including links to terrorism, human-rights abuses, and democratization in the Middle East (Tenet, 2007, 301). But WMDs played the central role in the U.S. administration’s arguments for forcible regime change. Ever since the President’s 2002 State of the Union Address, the U.S. administration had publicly declared that it would “not permit the world’s most dangerous regimes to threaten us with the world’s most destructive weapons” (Bush, 2002b). Two days later, President Bush reiterated the argument: “Saddam Hussein must understand that if he does not disarm, for the sake of peace, we, along with others, will go disarm Saddam Hussein” (CNN, 2003). On February 5, 2003, in what was the most publicized attempt to legitimize the invasion, Secretary of State Colin Powell made a presentation to U.N. Security Council titled ‘Iraq: Failing to Disarm.’ In it, Sec. Powell argued that “possession of the world’s most deadly weapons was the ultimate trump card [and] the United States would not – could not – run the risk to the American people that Saddam Hussein would one day use his weapons of mass destruction” (UN, 2003). The day after Baghdad fell, in the absence of any WMD findings on the ground, White House press secretary Ari Fleischer repeated it: “[W]e have high confidence that they have weapons of mass destruction. *That* is what this war was about and it is about” (emphasis added).24

This heightened perception of the threats posed by WMD proliferation for the United States is perhaps best captured by ‘the one percent doctrine,’ attributed to Vice President Dick Cheney. In the new security environment, the United States must deal with ‘low-probability, high-impact’ events as if they were certain (Suskind, 2006). If there is a one percent chance a great threat will materialize, U.S. policy must deal with it as if it were certain.

*Iraqi forces to have operated at the maximum effectiveness permitted by the technology at their disposal, the outcomes would have changed little* (Press, 2001).

24Later, in the absence of WMD findings, Paul Wolfowitz, one of the architects of the war, claimed that there were four motivations behind the invasion: Iraq’s WMDs, its support for terrorism, the nexus between these two, and the regime’s treatment of the Iraqi population. According to him, the administration settled on the WMD argument “for reasons that have a lot to do with the U.S. government bureaucracy we settled on the one issue that everyone could agree on” (Wolfowitz, 2003).

24
The impact of Iraq acquiring a nuclear capability was one such ‘low-probability, high-impact’ development. The United States feared not only that Saddam would hand a nuclear weapon off to a terrorist group for use against the U.S. homeland – it worried that any attempt to prevent it from doing so (or retaliate against having so done) would be exceedingly costly. Were Iraq to acquire nuclear weapons, its relative power vis-à-vis the United States would shift very significantly, curtailing the U.S.’s scope of action. Specifically, a U.S. attempt to depose Saddam by force would place him in a “use them or lose them” situation regarding his nuclear capability, and was therefore out of the question (Posen, 1997, 22-26). In short, a nuclear-armed Iraq would pose a grave risk to U.S. security, decrease the probability of a U.S. military victory, and multiply the costs of any U.S. military action against it. Therefore, though unlikely, Iraqi nuclear acquisition posed grave consequences, leading to U.S. preventive action. Put differently, according to this mindset, in the absence of certainty about Iraq not arming, the United States must act.

In sum, the crisis leading to the invasion of Iraq was grounded on a dispute about Iraqi efforts to acquire WMDs – a development the United States was determined to avoid. In the absence of information that proved Iraq was not investing in a WMD capability, the United States, possessing the ability to disarm it, could not and did not hesitate to do so. As Packer (2005, 60) puts it, the argument for the war was syllogistic:

Saddam has had and still seeks weapons of mass destruction; he has used them on his own citizens in the past; he might now give them to al-Qaeda or another terrorist group; terrorists want to destroy the United States. Therefore, the United States must disarm or overthrow Saddam.

According to the terms of the 1991 ceasefire, Iraq was forbidden from developing WMDs and long-range missiles. To verify Iraqi compliance, UNSCOM was created and its inspectors worked in the country until December 1998. Iraq, however, was repeatedly found in violation of its disarmament obligations (Ritter, 1999). By December 1998, after growing tension and U.S. airstrikes, UNSCOM was evicted of Iraq, still unable to verify Saddam’s disarmament. At the time, Scott Ritter, the Commission’s chief inspector, noted that “without effective monitoring, Iraq can in a very short period of time measure the months, reconstitute chemical biological weapons, long-range ballistic missiles to deliver these weapons, and even certain aspects of their nuclear weaponization program” (Ritter, 1998). In sum, the inspections regime imposed on Iraq
failed, with no U.N. certification of complete disarmament (Thompson, 2009).

It was only on September 26, 2002 – almost four years after inspections had ceased – that Saddam, under mounting international pressure, agreed to let U.N. inspectors back in. Earlier that month, the British International Institute for Strategic Studies concluded that Iraq possessed the scientific apparatus to “assemble nuclear weapons within months if fissile material from foreign sources were obtained” (Chapman, 2002, 4). In fact, Hans Blix, the chief inspector for UNMOVIC (which had replaced UNSCOM), was unable to ascertain whether Iraq possessed any WMDs. UNMOVIC’s work was plagued by discrepancies between Iraqi reports of WMD quantities produced and destroyed. According to Blix, UNMOVIC’s reports “do not contend that weapons of mass destruction remain in Iraq, but nor do they exclude that possibility. They point to lack of evidence and inconsistencies, which raise question marks, which must be straightened out, if weapons dossiers are to be closed and confidence is to arise” (Blix, 2003b). In his final pre-war presentation to the U.N. Security Council, Blix (2003a) was remarkably ambiguous:

It is obvious that, while the numerous initiatives, which are now taken by the Iraqi side with a view to resolving some long-standing open disarmament issues, can be seen as ‘active,’ or even ‘proactive,’ these initiatives 3-4 months into the new resolution cannot be said to constitute ‘immediate’ cooperation. Nor do they necessarily cover all areas of relevance.

Indeed, there was a broad political consensus in Washington that Saddam possessed, or intended to acquire, WMDs. Senator John Kerry from Massachusetts, soon to become the Democratic presidential nominee, stated: ‘According to the CIA’s report, all U.S. intelligence experts agree that Iraq is seeking nuclear weapons. There is little question that Saddam Hussein wants to develop nuclear weapons’ (Kerry, 2002, S10172-10173).

As it turned out, Iraq possessed no WMDs and had no consistent WMD programs. All the Iraq Survey Group could find after the invasion was evidence that Saddam intended to revive such programs if and when sanctions were lifted. The Group’s Final Report states:

Saddam wanted to recreate Iraq’s WMD capability – which was essentially destroyed in 1991 – after sanctions were removed. ... Saddam aspired to develop a nuclear capability – in an incremental fashion, irrespective of international pressure and the
resulting economic risks – but he intended to focus on ballistic missile and tactical chemical warfare (CW) capabilities (CIA, 2004, 1). 25

Much has been made of this intelligence failure (Bamford, 2004; Cirincione et al., 2004; Danchev, 2004; Prados, 2004; Isikoff and Corn, 2006; Phythian, 2006). But Robert Jervis convincingly dismisses the thesis that politicization was responsible for the intelligence failure on Iraq’s WMD. According to him, “the belief that Iraq had active WMD programs was held by all intelligence services, even those of countries that opposed the war” (Jervis, 2010, 134, Jervis’s emphasis). Furthermore, for Jervis, “while alternatives [to the picture intelligence reports painted of Saddam’s putative WMD programs] should have been considered, doing so probably would not have changed the estimates” (Jervis, 2010, 128). The problem was that in order to change U.S. policy, intelligence reports would have to prove that Iraq did not have and would not develop WMDs. But it is well nigh impossible for intelligence to prove a negative. As Jervis concludes:

At best, intelligence could have said that there was no firm evidence that Saddam had stockpiles of chemical and biological weapons or was actively pursuing nuclear bombs. It could not have said that he had ceased his efforts. ... Furthermore, intelligence could not have said that Saddam would not pursue of WMD at some point in the future (Jervis, 2010, 126).

The fundamental reason for the WMD intelligence failure in Iraq was that the inferences were very plausible, much more so than the alternatives. Saddam had vigorously pursued WMD in the past, had used chemical weapons to good effect, had powerful incentives to rebuild his programs, had funds, skilled technicians, and a good procurement network at his disposal, and had no other apparent reason to deceive and hinder the inspectors (Jervis, 2010, 146).

Indeed, given the absence of WMD capabilities, Saddam’s often obstructionist behavior during the 18 months that preceded the war, “was figuratively and indeed literally suicidal” (Jervis, 2010, 129). 26

25 For a previous report on WMD findings in Iraq after the invasion, see Kay (2004).
26 Saddam’s rationale appears to have been based on his estimate that, first, Russia or France would intercede on Iraq’s behalf, preventing war and, second, if that failed, Iraqi forces would
From the point of view of our theory, however, the crucial point is not whether the intelligence supported the policy of forcible overthrow of the Iraqi regime or not. Rather, it is that the information received by the United States about Iraq’s WMD capabilities and development programs was imperfect. Simply put, based on such imperfect information “[a] responsible judgment could not have been that the programs had ceased” (Jervis, 2010, 155). It is the imperfect nature of intelligence information that explains why war occurred despite successful counterproliferation.

To summarize, by 2002-2003, the United States possessed an overwhelming power advantage over Iraq. Such power differential made possible a sanctions regime that had log ago forced Saddam to cease his nuclear program. But when a heightened perception of the threat posed by Saddam’s putative WMD capability led the United States to focus on the need to ensure Iraq’s disarmament, U.S. decisionmakers were never able to obtain definitive information about Iraq’s decision to forfeit nuclear acquisition. Consequently, the United States proceeded to invade Iraq despite its success in deterring Saddam from acquiring a nuclear capability. Possessing preponderant power and unable to obtain perfect information, the United States were undeterred in launching a preventive war against Iraq.

In this section, we provided two case studies to illustrate the logic of our argument, highlighting the differences between the Cold War and the post-Cold War periods. Beyond these cases, we think the argument is generalizable by considering a country’s pre-nuclear relative power and its alliance status. We expect the effect of investment on the balance of power to be smaller for countries that (i) already possess significant conventional power, (ii) are allied with a great-power sponsor, or both; than for neutral countries with little relative power. The logic is straightforward: possession, or alliance with, significant relative relative power reduces the effect of nuclearization. At the same time, it increases the costs of preventive war.

Given our model, then, neutral countries with small conventional forces are not very likely to acquire nuclear weapons. The empirical pattern seems to confirm this intuition. Among neutral states, only a few with relatively powerful conventional forces – e.g., China – managed to acquire nuclear weapons. Both the US and the Soviet Union considered a preventive war, but decided against it given the cost of a preventive war (Burr and Richelson, 2000-01; Gavin, 2004-05) be capable of increasing the military costs for the United States to the point at which American public opinion would force Washington to back down (Woods et al., 2006, 28-32)
Less powerful neutral countries like Sweden and Switzerland, however, never acquired nuclear weapons despite their status as likely proliferators at the start of the Cold War. It is well documented that one of the reasons for their decision not to acquire nuclear weapons was the fear of a preventive strike by the Soviet Union (Paul, 2000, chapter 5). At the same time, it is hardly conceivable that the Soviet Union would strike France or Great Britain to prevent their acquisition of nuclear weapons. These are two countries with relatively large conventional forces and the support of a great-power sponsor. We plan to explore these cases in further detail in future work.

5 Conclusion

The last two decades have witnessed a resurgence in nuclear alarmism, leading to a consensus around the position that “the world again is approaching a tipping point that could lead to a nuclear proliferation epidemic” (Potter and Mukhatzhanova, 2010a, 1-2). But the predictions of successive waves of pessimism about the future of non-proliferation have failed to materialize. In fact, one of the greatest puzzles of international politics since 1945 is “the failure of nuclear proliferation to assume a pandemic-like dynamic” (Muller and Schmidt, 2010, 124). Even strong pessimists such as Graham Allison, acknowledge that – with the possible exception of North Korea – “[t]here are no more nuclear weapons states now than there were at the end of the Cold War” (Allison, 2010).

We are skeptical of the more pessimistic predictions about nuclear proliferation. The absence of a systemic balance of power, contrary to what is commonly believed, places an important brake on proliferation dynamics. By making any dyad between the United States and a would-be proliferator unbalanced, power preponderance increases the potential shift in the balance of power that would result from nuclear acquisition. At the same time, it decreases the costs of (U.S.-launched) preventive war. Taken together, these two factors make proliferation less likely – and preventive war more likely, even against non-proliferating states.

Our argument has important implications for the deterrence literature. The model described above highlights how deterrence – in this case, counterproliferation – may fail despite credible threats. The would-be proliferator’s uncertainty about whether compliance will be rewarded generates the possibility of proliferation in the face of credible threats of preventive military action. This failure of deterrence caused by non-credible assurances is particularly important
in situations of lower costs of war, as when a powerful state is attempting to deter a relatively weak state. We believe this is a potentially fruitful insight that should lead to a revision of deterrence models when a balance of power is absent.

Our theory also highlights several points of interest for our understanding of nuclear proliferation. Aside from the unequalled destructive power of nuclear weapons, the proliferation process presents particularly thorny problems for reasons patent in our model. Nuclear programs can be hidden with relative ease. They can also, given their dual-use nature, be portrayed as having non-military purposes. These factors decrease the quality of the information about a state’s decision to acquire nuclear weapons, making it harder to be certain of what that decision is. This dynamic generates incentives for preventive war, particularly when the costs of such war are relatively low. At the same time, however, states developing nuclear programs usually disperse them, raising the costs of a hypothetical preventive strike. This attenuates incentives for preventive war. Overall, this combination of factors provides states that want to proliferate with an incentive to make the signals it emits “insufficiently informative” in order to avoid certain attack. This explains why potential proliferators deploy strategic ambiguity about their nuclear programs – a clear signal of an investment in nuclear capability, might invite a preventive attack.

Furthermore, our theory hints at problems with each of the three traditional counter-proliferation approaches – containment, engagement, and preventive war. Containment and sanctions, by making the status quo less favorable to would-be proliferators, actually encourage the development of nuclear capabilities as a means to guarantee a better future situation. Engagement, by making the status quo more favorable to would-be proliferators, is likely to be perceived as a short-term ploy, since the current balance of power would not – should the target abdicate from its nuclear aspirations – justify maintaining this situation in the future. And, since nuclear proliferation has a large effect on the balance of power, the probability that a preventive war will be launched against an innocent state is at its greatest. Each policy option presents its own problems.

The theory laid out here also accounts for the structural origins of preventive counter-proliferation wars. In a nutshell, we explain why mistaken preventive wars are more likely under unipolarity. The Iraq war, in this view, was not the result of any idiosyncratic policy preferences by the Bush administration (Jervis, 2003, 317). Much to the contrary, Iraq was made possible
by the conditions laid out in our theory. In fact, preventive war has been consistently considered by all post-Cold War U.S. administrations. In 1994, President Clinton was reportedly within minutes of deciding whether to use force against North Korea when news of a negotiating breakthrough came in. As Trachtenberg (2007, 19) writes, “the policy the Clinton administration pursued toward North Korea in 1994 was cut from the same cloth as the Bush strategy.” In short, preventive war has consistently been at the center of the U.S.’s counterproliferation policy since the end of the Cold War.

More recently, dealing with Iran, William Perry and Ashton Carter – both high-ranking officials in the Clinton administration, the latter also serving under President Obama – have written, “Should the United States allow a country openly hostile to it and armed with nuclear weapons to perfect an intercontinental ballistic missile capable of delivering nuclear weapons to U.S. soil? We think not” (Carter and Perry, 2006). The Iranian nuclear program has consistently been one of the foremost concerns of U.S. administrations for the past decade. As it progresses, it is likely that debate on how to prevent Iran from acquiring nuclear weapons will intensify. As we have seen, containment and sanctions can have counterproductive effects. The lesser the ability of the Iranian state to achieve its policy goals without nuclear weapons, the greater the drive towards proliferation. Engagement, for its part, presents serious commitment problems. There is no good reason for Iranian leaders to believe the credibility of U.S. promises of greater future cooperation, were they to stop their nuclear program. If their current relative power is such as to only warrant their current status in the international system, there is no good reason the United States would keep any promises of better relations in the future, once the object of dispute – Iran’s nuclear program – is no longer an issue. Finally, preventive war, besides presenting pointed moral dilemmas, may fail to settle the problem conclusively, merely delaying its denouement. And yet, a preventive strike against Iran by the United States or one of its client states (e.g., Israel) is in no way out of the question. For as long as the United States remains the preponderant power in the international system, the costs of preventive military action to counter nuclear proliferation will be lower than the potential shift in the balance of power that would ensue nuclear acquisition by a state not aligned with Washington. Such are the structural constraints connecting nuclear proliferation with preventive war.
6 Appendix

Proof. (Proof of Proposition 2). The equilibrium in period 1 is: \( m^* = 1 \) if and only if

\[
\delta w_T (1) - (1 + \delta) w_T (0) \leq 1 - w_T (0) - w_D (0) \tag{6}
\]

If \( m = 0 \), \( D \) offers \( z_1^* = w_T (0) \) and if \( m = 1 \), \( D \) offers \( z_1^* = 0 \) if condition (6) holds and declares war otherwise; \( T \) accepts any \( z_1 \in [0,1] \) if \( m = 1 \) and accepts \( z_1 \geq w_T (0) \) if \( m = 0 \).

We establish this result by backward induction. \( T \) accepts \( z_1 \) if and only if

\[
z_1 + \delta w_T (m) \geq (1 + \delta) w_T (0) \implies z_1 \geq w_T (0) - \delta (w_T (m) - w_T (0)) \tag{7}
\]

The right-hand side of (7) is \( w_T (0) \) for \( m = 0 \) and it is negative for \( m = 1 \), by (2) and \( k > 0 \).

Moving up, \( D \) chooses between war and offering \( z_1 = w_T (0) \) if \( m = 0 \) and \( z_1 = 0 \) if \( m = 1 \). If \( m = 0 \), \( D \) prefers to offer \( z_1 = w_T (0) \) since war is costly. If \( m = 1 \), \( D \) prefers to offer \( z_1 = 0 \) if and only if \( 1 + \delta (1 - w_T (1)) \geq w_D (0) + \delta (1 - w_T (0)) \), which reduces to (6).

Moving up, if (6) holds, \( T \) prefers to invest if \(-k + \delta w_T (1) \geq (1 + \delta) w_T (0) \), which holds by (2). If (6) does not hold, \( T \) prefers not to invest since \(-k + (1 + \delta) w_T (0) < (1 + \delta) w_T (0) \). \( \blacksquare \)

Proof. (Proof of Proposition 3). The equilibrium in period 1 is: \( T \) invests with probability

\[
q^* = \begin{cases} 
1 & \text{if condition (6) holds} \\
\frac{1 - w_T (0) - w_D (0)}{\delta (w_T (1) - w_T (0))} & \text{otherwise}
\end{cases}
\]

If condition (6) holds, \( D \) offers \( z_1^* = 0 \). If condition (6) does not hold, \( D \) offers \( z_1^* = w_T (0) \) with probability \( r^* = \frac{k}{\delta (w_T (1) - w_T (0))} \) and declares war with probability \( 1 - r^* \); \( T \) accepts any \( z_1 \in [0,1] \) if \( m = 1 \) and accepts \( z_1 \geq w_T (0) \) if \( m = 0 \).

We solve this game by backward induction. \( T \)’s response to \( z_1 \) is as given in proposition 2.

Moving up, \( D \)’s optimal strategy is to choose between one of two actions: the optimal response to \( T \) not arming and the optimal response to \( T \) arming, as given in proposition 2. Write \( r^* \) for the equilibrium probability that \( D \) offers \( z_1^* = w_T (0) \).

If condition (6) holds, then \( T \) invests with probability \( q^* = 1 \) and \( D \) offers \( z_1^* = 0 \). Indeed, \( T \) prefers to invest if \(-k + r^* w_T (0) + \delta w_T (1) > (1 + \delta) w_T (0) \), which holds by (2). Therefore,
T chooses \( q^* = 1 \) and, as a result, \( D \) strictly prefers to offer \( z_1^* = 0 \).

If condition (6) does not hold, the equilibrium has \( T \) using a mixed strategy, as argued in the text. This is a best response for \( T \) only if \( T \) is indifferent between investing and not investing, i.e. if

\[
-k + (1 - r^*) (1 + \delta) w_T (0) + r^* [w_T (0) + \delta w_T (1)] = (1 + \delta) w_T (0)
\]

or if \( r^* = \frac{k}{\delta w_T (1) - w_T (0)} \). \( r^* \in (0, 1) \) means that \( D \) also plays a mixed strategy, which is optimal only if declaring war brings the same payoff as offering \( z_1 = w_T (0) \), i.e. if

\[
w_D (0) + \delta (1 - w_T (0)) = 1 - w_T (0) + \delta (1 - [(1 - q^*) w_T (0) + q^* w_T (1)])
\]

or \( q^* = \frac{|1 - w_T (0) - w_D (0)|}{\delta [w_T (1) - w_T (0)]} \in (0, 1) \). ■

Proof. (Proof of corollary 1).

(i) The probability of war is zero if condition (6) holds. Otherwise, it is \( 1 - \frac{k}{\delta w_T (1) - w_T (0)} \), which increases with \( \delta w_T (1) - (1 + \delta) w_T (0) \), everything else equal.

(ii) The probability of successful deterrence is zero if condition (6) holds. Otherwise, it is \( 1 - \frac{1 - w_T (0) - w_D (0)}{\delta [w_T (1) - w_T (0)]} = 1 - \frac{1 - w_T (0) - w_D (0)}{\delta w_T (1) - (1 + \delta) w_T (0) + w_T (0)} \), which increases with \( \delta w_T (1) - (1 + \delta) w_T (0) \), everything else equal.

(iii) The probability that wars are fought against an unarming \( T \) is equal to the probability of deterrence being successful, conditional on war. No wars are fought if condition (6) holds. Otherwise, the success of deterrence and war are two independent events, so that the probability of deterrence being successful, conditional on war, reduces to the probability of successful deterrence. The results follow from (ii). ■

Proof. (Proof of proposition 4). The equilibrium in period 1 is: If condition (6) holds, \( T \) invests with probability \( q^* = 1 \); \( D \) offers \( z_1^* = 0 \) for any \( s_1 \); \( T \) accepts any \( z_1 \in [0, 1] \) if \( m = 1 \) and accepts \( z_1 \geq w_T (0) \) if \( m = 0 \).

If condition (6) does not hold, then \( T \) invests with probability

\[
q^* = \begin{cases} 
0 & \text{if condition (3) holds} \\
\frac{1}{p_s + (1 - p_s) \frac{2[w_T (1) - w_T (0)]}{w_T (0) - w_D (0)}} & \text{otherwise}
\end{cases}
\]

If she receives signal \( s_1 = 1 \), \( D \) declares war. If she receives signal \( s_1 = 0 \), then \( D \) offers \( z_1 = w_T (0) \) if condition (3) holds and otherwise offers \( z_1 = w_T (0) \) with probability \( r^* = \frac{1}{p_s + (1 - p_s) \frac{w_T (0) - w_D (0)}{w_T (0) - w_T (1)}} \).
\[
\frac{k}{(1-p_s)[w_T(1)-w_T(0)]} \text{ and declares war with probability } 1 - r^*; \ T \text{ accepts any } z_1 \in [0, 1] \text{ if } m = 1 \text{ and accepts } z_1 \geq w_T(0) \text{ if } m = 0.
\]

We solve the game by backward induction. \(T\)’s response to \(z_1\) is as given in proposition 2.

Moving up, \(D\)’s optimal strategy is to choose between one of two actions: the optimal response to \(T\) not arming and the optimal response to \(T\) arming, as given in proposition 2. Since signal \(s_1 = 1\) can only come from an arming \(T\), then after such a signal, \(D\) offers \(z_1 = 0\) if condition (6) holds and declares war otherwise. Now write \(r^*\) for the probability that \(D\) offers \(z_1 = w_T(0)\) after receiving signal \(s_1 = 0\).

If condition (6) holds, then \(T\) invests with probability \(q^* = 1\) and \(D\) offers \(z^*_1 = 0\) when receiving signal \(s_1 = 0\). Indeed, \(T\) prefers to invests if \(-k + (1 - p_s) r^* w_T(0) + \delta w_T(1) > (1 + \delta) w_T(0)\), which holds given (2). Therefore, \(T\) chooses \(q^* = 1\) and, as a result, \(D\) strictly prefers to offer \(z^*_1 = 0\) when receiving signal \(s_1 = 0\).

Now assume that condition (6) does not hold. First, we show that \(T\) invests with probability \(q^* < 1\). Indeed, assume otherwise, then \(D\)’s best response is to declare war, but then \(T\)’s best response is to invest with probability \(q^* = 0\).

Second, \(T\) invests with probability \(0\) only if (3) holds. Indeed, if \(T\) does not invest, then \(D\)’s best response is to offer \(w_T(0)\). \(T\) has no incentive to deviate if and only if the payoff of not investing is at least as large as the payoff of investing:

\[
(1 + \delta) w_T(0) \geq -k + (1 - p_s)(1 + \delta) w_T(0) + (1 - p_s)[w_T(0) + \delta w_T(1)]
\]

which reduces to (3).

Third, if (3) does not hold, then \(T\) uses a mixed strategy. This is optimal only if the payoff of not investing is equal to the payoff of investing, i.e. if

\[
(1 + \delta) w_T(0) = -k + (p_s + (1 - p_s)(1 - r^*)) (1 + \delta) w_T(0) + (1 - p_s) r^* [w_T(0) + \delta w_T(1)]
\]

or \(r^* = \frac{k}{(1-p_s)[w_T(1)-w_T(0)]}\), \(r^* \in (0,1)\) means that \(D\) also plays a mixed strategy, which is optimal only if declaring war brings the same payoff as offering \(z_1 = w_T(0)\), i.e. if

\[
w_D(0) + \delta (1 - w_T(0)) = 1 - w_T(0) + \delta \left[ 1 - \frac{(1 - q^*) w_T(0) + q^* (1 - p_s) w_T(1)}{(1 - q^*) + q^* (1 - p_s)} \right]
\]

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\[ q^* = \frac{1}{p_s + (1-p_s) \delta \frac{[w_T(1)-w_T(0)]}{1-w_T(0)-w_D(0)}}. \]

**Proof.** (Proof of corollary 2). Results are trivial if (3) holds. Assume that (3) does not hold.

(i) The probability of war is zero if condition (6) holds. Otherwise, it is

\[
1 - (1 - q^* p_s) r^* = 1 - \frac{k}{p_s \left[1 - w_T(0) - w_D(0)\right] + (1 - p_s) \delta \left[w_T(1) - w_T(0)\right]} \left[1 - \left(1 - w_T(0) + w_T(0)\right)\right]
\]

which increases with \( \delta w_T(1) - (1 + \delta) w_T(0) \), everything else equal.

(ii) The probability of successful deterrence is zero if condition (6) holds. Otherwise, it is

\[
1 - q^* = 1 - \frac{1}{p_s + (1-p_s) \delta \frac{[w_T(1)-w_T(0)]}{1-w_T(0)-w_D(0)}} = 1 - \frac{1}{p_s + (1-p_s) \delta \frac{w_T(1) - (1+\delta) w_T(0) + w_T(0)}{1-w_T(0)-w_D(0)}}
\]

which increases with \( \delta w_T(1) - (1 + \delta) w_T(0) \), everything else equal.

(iii) The probability that wars are fought against an unarming \( T \) is the probability of deterrence being successful, conditional on war. No wars are fought if condition (6) holds. Otherwise, write this probability \( p(d|w) \). We have

\[
p(d|w) = \frac{(1 - q^*) (1 - r^*)}{(1 - q^*) (1 - r^*) + q^* \left[1 - r^* + p_s r^*\right]} = \frac{1}{1 + \frac{q^*}{1 - q^*} \left(1 + p_s \frac{r^*}{1 - r^*}\right)}
\]

Let \( \Delta = \delta w_T(1) - (1 + \delta) w_T(0) \). Since \( \frac{\partial q^*}{\partial \Delta} < 0 \), \( \frac{\partial r^*}{\partial \Delta} < 0 \), we have

\[
\frac{\partial p(d|w)}{\partial \Delta} = -\left[p(d|w)\right]^2 \left[\frac{\partial q^*/(1-q^*)}{\partial \Delta} \left(1 + p_s \frac{r}{1 - r}\right) + \frac{q^*}{1 - q^*} p_s \frac{\partial r^*/(1 - r^*)}{\partial \Delta}\right] > 0
\]

**References**


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Figure 1: Timeline of nuclear proliferation

Data from Fuhrmann (2009a). The dataset has two dates for India’s nuclear acquisition -- 1974 and 1988. We display only the date of initial acquisition. There is some debate about the timing of Pakistan’s acquisition. Singh and Way (2004) place it in 1990, but we think this is overly cautious, since Pakistan had at least one bomb assembled by 1987 (Fuhrmann, 2009a, 20-23). We follow Singh and Way (2004), though, on placing South African nuclear disarmament at 1993, the date President de Klerk announced his country had dismantled all nuclear weapons. Neither dataset goes beyond 2000. We add North Korean acquisition in 2006, following its October 9 test. Responding to doubts about the effectiveness of this test, North Korea tested a second nuclear weapon on May 25, 2009.