Militarization, Negotiations, and Conflict*

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Abstract

We situate a growing theoretical literature on strategic militarization in a family of connected parsimonious models in order to flesh out how important institutional or environmental features impact the equilibrium level of arming and risk of fighting. Key comparisons allow us to assess the influence of negotiation dynamics and whether arming decisions are hidden or public. Through the comparison of these models, we help clarify how several structural features interact. We also trace out the central logic behind deterrence, signaling and preventative fighting. A key focus is on the economic and social repercussions of these strategies, and an assessment of which features in the environment are central to the emergence of various forms of behavior. Understanding these behaviors is crucial for scholars and policymakers navigating the complexities of international security and military strategy, and the ability to support a broad range of circumstances in a simple family of models helps to clarify how primitive assumptions relate to equilibrium phenomena.

1 Introduction

For all the attention that the decision to go to war receives, far less attention has been given to the impact of militarization policies on crises, negotiations, and the probability of open warfare. Militarization, the acquisition of arms and mobilization of armies, is in most cases a prerequisite for countries to be able to go to war. In fact, the flow of crises is often determined by a state's needs to militarize, with World War I's mobilization timetables being the most extreme example.

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Understanding the incentives for militarization and how arming choices impact decisions about negotiations and war-fighting is crucial for analyzing international relations and conflict. In this chapter, we present a survey describing the state of our theoretical understanding of these incentives and explore how features of the strategic interaction between states during a crisis affect militarization decisions.

There are generally two channels by which militarization decisions affect conflict. First, militarization can impact the decisions to use force, influencing the probability of war. A state may refrain from fighting if it believes its opponent has militarized. Second, because militarization alters the willingness to fight, it can affect the terms of proposed settlements, shaping the outcomes of negotiations. Thus, in most work, the bottom line is an examination of how militarization, and features that shape militarization decisions, impact the odds of conflict and the terms of settlement.

One important environmental feature that influences militarization incentives is its observability. The degree to which other countries can observe a nation's military buildup can have significant implications for negotiations and the likelihood of war. If militarization is observable, it can serve as a deterrent to potential aggressors. On the other hand, if it is difficult to observe, the possibility that militarization is happening can create strategic uncertainty, potentially increasing the risk of war.[1]

Scholars also consider arming to be a choice made in settings where participants face real uncertainty about each other's intentions. They see arming as a possible form of signaling. By building up its military capabilities, a country can signal its resolve to other nations. This can influence the behavior of other countries in negotiations, and potentially deter aggression. However, signaling through militarization can also be risky, as it can change the incentives to fight and may provoke other countries to respond with their own military buildups.

In this chapter, we will explore these and other aspects of militarization in detail. We will draw on the existing literature to provide an overview of the topic and offer insights into how militarization affects negotiations and the incidence of war-fighting. Through our analysis, we aim to provide an in-depth understanding of this complex and important issue and provide future scholars with an overview of the types of models that have been used to explore this topic.

The chapter is organized around a central model of strategic interaction. To capture the results of complex models in a concise and accessible fashion, we develop a simple two-player game in which there is a militarization decision and then a crisis in which

[1] This kind of unobservable action, called misperception, is one of the main topics in the chapter in this volume by Acemoglu and Wolitzky (2024).

war may occur. States ultimately care about a resource or issue, which in some models can be divided through a settlement or by capitulating to demands. If war occurs, we abstract from the war-fighting process and assume the issue is resolved randomly. In othwer words, war is conceived as a lottery over some prize and militarization decisions will effect the probabilities in this randomization. Additional war-fighting costs may be accrued. Through various modifications to our simple game, we can present stylized versions of strategic incentives that form the basis of much of the literature. This allows one to get a handle on the richness of strategic interactions and tradeoffs and provides some sense of how structural circumstances and modeling assumptions impact the kinds of behavior that may emerge in equilibrium.

The goal of this chapter is to help researchers appreciate the key strategic forces and tradeoffs involved in militarization decisions. We purposely abstract away from certain details in published work, highlighting only a subset of the findings in key publications, and we do not claim to exhaustively review all the relevant and important research. That is to say, our chapter is itself a model review, we abstract away from some issues that have been raised by scholars to paint a somewhat easier to understand and coherent picture of the state of scholarship.

To be sure, theoretical research on strategic militarization is only a small subset of the body of research on militarization strategies. That being said, our focus here is on this subset as a large share of the broader, often empirical, literature contains core ideas or arguments that are derived from work employing game-theoretic logic and predictions.[2]

2 Basics of Strategic Arming

We begin by presenting a simple framework that we will modify in many ways. Consider the situation faced by two countries in a potential dispute that could lead to war. Country A is the leader, and to begin we will treat their level of military capacity as fixed. Country B is a potential challenger, and our goal initially is to understand why and when they might choose to militarize.

To start, militarization is treated as a binary choice by B. They may pay a cost k to

[2] This review focuses on recent work that has connected strategic arming and the bargaining model of war, building on ideas exemplified by the classic analysis of Richardson (1960) and Jervis (1978). For reviews of these earlier works see Intriligator and Brito (1976) and Downs, Rocke and Siverson (1985). These reviews primarily focus on Richardson style models, classic 2 by 2 normal form games in their analysis of arms races, and empirical studies of arms races. While important, they do not directly connect to the contemporary international relations literature, which typically places war, and consequently arms races, within the frameworks that interpret war as a form of international bargaining occurring in the shadow of potential conflict. For a discussion of the empirical literature, also see Glaser (2000).

become stronger, or they may retain their current level of military capacity. In all variants of the model, there are two kinds of outcomes. The interaction between A and B may end peacefully, in which case a resource of size one is efficiently split between the two players. In a peaceful outcome, let x (with $0 \leq x \leq 1$) denote the share to A and $1 - x$ denote the share to B. Alternatively, the interaction may end in war.

The payoffs to war depend on the militarization decision of B. The relative strength of B impacts the odds that B wins. To capture the effect of arming, assume the probability that B wins when they are unarmed is w, and s when they are armed, with $w < 1/2 < s$. In the sequel, the arming choices of both A and B will jointly determine war payoffs.

As is standard in the literature, assume that war-fighting is costly. Let θ denote the destructiveness of war, where $(1 - \theta)$ is the size of the prize after war. In particular, we assume that the payoffs from fighting to A, B are given by

$$\{u_A(war), u_B(war)\} = \begin{cases} \{(1-s)(1-\theta), s(1-\theta)\} & \text{if } B \text{ arms} \\ \{(1-w)(1-\theta), w(1-\theta)\} & \text{if } B \text{ does not arm} \end{cases}$$

Under this construction, war is a lottery that assigns the reduced prize to Country A with probability $1 - p$ and to B with probability p, where the value of $p \in \{s, w\}$ depends on arming strategies.

War-fighting may be a more complicated process, but at the time of choosing to fight, the option is evaluated at its expected value. We are assuming that actors are risk-neutral, though the qualitative nature of the trade-offs countries face are not significantly affected if they are risk-averse in these models.

As we will see, an important condition for determining whether arming can be rationalized is encapsulated in the following assumption:

Assumption 1. *For the rising state, the cost of arming is smaller than the difference in expected war payoffs between being strong and weak.*

$$(1 - \theta)(s - w) > k.$$

If this condition fails, and $(1 - \theta)(s - w) < k$, then the cost of arming simply outweighs the gain that a state can obtain on the battlefield from choosing to arm. In the class of models considered here, the gains that a state can generate in a peaceful settlement are also tied to what they could gain from fighting and so, when Assumption 1 fails, the cost is decisive and B will choose not to arm.

We now build on these fundamentals to analyze a series of models aimed at showing how the observability of militarization, the nature of crisis negotiations, the information environment, as well as assumptions about the sequence of interactions, shape militarization incentives and the relationship between arming and fighting.

As mentioned, the literature in general, and our collection of models in particular, assume that countries care primarily about their share of the resources and possible costs and benefits from fighting. Moving from actors objectives to measures of welfare, or socially relevant outcomes, the key metrics tend to be the probability of war and, to the extent that militarization typically involves costs, the probability that B arms. Thus, whenever possible, we will tie our analysis back to these measures.

3 Public Arming

To start, consider a simple game in which first B decides to arm, then, after observing this choice A and B decide whether to initiate conflict or maintain a fixed status quo split $(x, 1-x)$. This model focuses attention on arming incentives alone, but can also apply to situations where an issue has a limited number of feasible peaceful divisions.

If any country chooses to fight, there is a war. Otherwise, there is peace that divides the benefit of the resource between the two countries at $(x, 1-x)$. For any fixed parameterization of the exogenous split, x, the payoffs to the conflict game are shown in Figure 1.

A \ B	Fight	$\neg$ Fight
Fight	$(1-s)(1-\theta), s(1-\theta)$	$(1-s)(1-\theta), s(1-\theta)$
$\neg$ Fight	$(1-s)(1-\theta), s(1-\theta)$	$x, 1-x$

(a) B arms

A \ B	Fight	$\neg$ Fight
Fight	$(1-w)(1-\theta), w(1-\theta)$	$(1-w)(1-\theta), w(1-\theta)$
$\neg$ Fight	$(1-w)(1-\theta), w(1-\theta)$	$x, 1-x$

(b) B does not arm

Figure 1. Two simultaneous 2x2 games with payoffs

Given arming choices, we see that, for A, not fighting weakly dominates fighting if $u_A(war) < x$, and fighting weakly dominates not fighting if the inequality goes the other way. Similarly, we can see when fighting or not fighting are weakly dominated for B

given their arming choices. We focus on equilibria in which war-fighting decisions are not weakly dominated.

Moving up to the choice to militarize by B there are two potential benefits to arming. First, if A is going to initiate conflict independent of B's strength, then the benefit of arming is captured by $(1-\theta)(s-w)$. In order for A to initiate conflict independent of B's strength, we must have $(1-s)(1-\theta) \geq x$

Thus, arming to fight is an equilibrium phenomenon if two conditions hold:

$$(1-s)(1-\theta) \geq x \text{ and,}$$
$$(1-\theta)(s-w) \geq k.$$

The other potential benefit occurs when arming deters conflict so that $(1-w)(1-\theta) \geq x \geq (1-s)(1-\theta)$. The benefit to B is then $1-x-(1-w)(1-\theta)$. Thus, arming to deter is an equilibrium phenomenon if two conditions hold:

$$(1-w)(1-\theta) \geq x \geq (1-s)(1-\theta) \text{ and,}$$
$$1-x-(1-w)(1-\theta) \geq k.$$

A complete characterization of the equilibrium in this game is straightforward.[3]

Proposition 1. *Suppose Assumption 1 and $\theta > (1-\theta)(s-w)$ are satisfied. Generically there is a unique Nash equilibrium in weakly undominated strategies.*[4] *The path of play is as follows: A tranquil path of play (no war, no arming) occurs whenever $(1-w)(1-\theta) < x < 1-s(1-\theta)+k$. A deterrent path (arming, no war) that features arming but no war occurs whenever $(1-s)(1-\theta) < x < (1-w)(1-\theta)$. A war-fighting path (arming, war) occurs whenever $x < (1-s)(1-\theta)$ or $x > 1-s(1-\theta)+k$.*

3.1 Public Arming with Bargaining

We now consider a richer environment where Country A can make a credible offer to split the resource through a simple take-it-or-leave-it offer. Though several scholars consider

[3]To reduce cases, we make the natural additional assumption that the costs of war are greater than the advantage from arming, though below we consider a situation where that may not be the case.

[4]The equilibrium is not unique only for the knife-edged set of parameters where some of the above inequalities hold weakly.

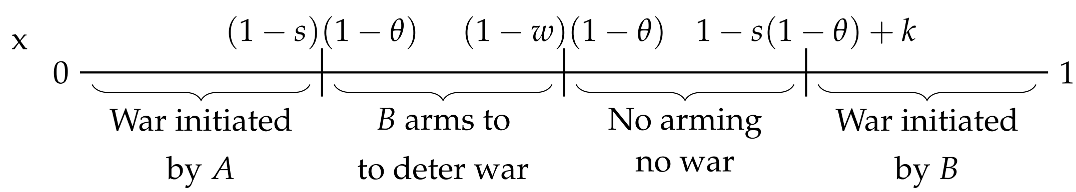

Figure 2. Arming Without Bargaining: When countries cannot bargain, arming can be used to deter a rival from going to war.

more complicated bargaining environments (e.g., Powell 1996; Fey and Ramsay 2011; Bas and Coe 2012), most of the key insights of the literature can be achieved within this simple and commonly employed modeling strategy.

We begin by allocating proposal rights entirely to A. Explicitly, the game form involves a public decision to arm (or not) by B, as in the first model, and then A makes a take-it-or-leave-it offer $(x, 1-x)$ to split the pie. B then accepts or rejects the offer. A rejection leads to the war payoffs described above, and acceptance leads to payoffs x to A and $1-x$ to B.

In any subgame perfect equilibrium, A must make the offer which makes B indifferent between fighting and peaceful settlement at $1-x$ and B must resolve their indifference by accepting this offer. In particular, following arming, the offer to B is $(1-\theta)s$ and following no arming, the offer to B is $(1-\theta)w$. Moving up to the arming decision, B will arm if and only if the gain in war payoffs from arming is sufficient to offset the cost of arming. This is our Assumption 1 above. It is important to note that this condition is relevant even though there is no risk of actually fighting in this model. So here the path of play mirrors what we called a deterrence equilibrium above–arming but not fighting. Here, however, it is less clear that we should call this deterrence behavior because if B had not armed, there would have also been peace, just with a different agreement.

Proposition 2. *Under Assumption 1, there is a unique subgame perfect equilibrium to the bargaining game with public arming, where the path of play involves arming and then the acceptance of the offer* $(1-(1-\theta)s, (1-\theta)s))$.

A few comments are in order. First, with strategic militarization some friction, like an inability to commit to alternative splits of the pie or, as we will see, private information is needed to generate a risk of inefficient war. However, the baseline model also demonstrates that the incentive to arm can exist even without the occurrence of actual conflict. In this model, militarization serves the role of an investment that raises the share of the pie that B can legitimately expect (and obtain through equilibrium play in the bargaining game).

Interestingly, the ability to commit to arming before bargaining is not necessary. Even if the arming decision occurred after a bargain was rejected, but before a war began, by Assumption 1 B would choose to arm. In this case, the credible threat to arm would be sufficient to receive the better distribution of benefits for B. Of course, whether it is reasonable to think that arming can occur quickly enough to make a model with bargaining followed by arming, followed by fighting reasonable is an open question.

Finally, the path of play involves arming and no fighting, which might seem like an example of deterrence, but as noted above, the equilibrium reveals that absent arming we would still not see fighting. We want to emphasize that the equilibrium analysis illustrates why one should be cautious in drawing conclusions about the effects of arming from observations of just a path-of-play. One needs to have in mind an equilibrium in a specific strategic context to understand how militarization impacts things like the incidence of war.

This analysis suggests that countries may sometimes find it beneficial to arm others. Qiu (2022) studies a model of arming in which a country can choose to split an exogenously given budget on arms between itself and a rebel group operating in a target country, who must then divide its resources to meet both threats. Qiu shows that when arming the rebel group is cost-efficient, the target state can increase its share of the bargaining surplus by arming the rebel group.

3.2 Costly Peace

Though arming may be an efficient way to extract surplus in a one-shot game, it may not necessarily be efficient in the long run. If countries need to continuously invest in arms to extract a bargaining surplus, they may prefer to arm and then start a war immediately in an attempt to eliminate their rival, rather than face the prospect of repeatedly paying the cost of arming to acquire the benefits of being strong while bargaining over many periods. This dynamic has been described as war due to the “costly peace” dynamic, since it illustrates that peace can be “more inefficient than war" in repeated interactions Coe (2011, p. 7).[5]

For example, Israel’s military has long relied on reservists to provide the bulk of its military strength in times of war. In the lead up to the Six Day War, Israel mobilized large numbers of reservists to counteract an Egyptian mobilization and prepare for the conflict

[5] Also see Garfinkel and Skaperdas (2000), where they show that because fighting today can weaken rivals in the future, requiring less arming, the short-term benefits of peace can be out weighed by the long-term benefit of war.

Churchill (1967, Ch. 3). Increasing numbers of troops remained mobilized for several weeks while diplomatic maneuvers and other preparations for war were being made. This mobilization put an immense strain on the economy, as the country's workforce was drained to meet military needs. This dynamic contributed to Israel's decision to launch a war against Egypt on June 5th 1967.

To better understand the costly peace argument, consider the following simple example. Suppose that the bargaining game is now a stage game played repeatedly over an infinite number of discrete periods $t = 0, 1, 2, ..., \infty$ and both countries have a common discount factor $\delta \in (0, 1)$. We assume that Country B cannot stockpile arms and so must repeatedly reinvest k to arm every period if it wishes to extract the diplomatic benefits of military strength. Moreover, we will assume that if the countries go to war, then the game ends and the winner of the war will get to enjoy the share of the good $1 - \theta$ that remains every period in perpetuity.

In such a game, the long run cost of arming to support a favorable peaceful settlement every period can be outweighed by the option of fighting today and effortlessly consuming the somewhat damaged resource in the future.

We describe a simple strategy profile that exhibits the path of play-showcasing the logic behind the costly peace argumentâand then show that it is an equilibrium if δ is sufficiently high and arming is sufficiently costly relative to the destructive nature of war.[6] The strategy involves B arming in every period where war has yet to occur and rejecting any offer that is made by A which does not give B at least $s(1 - \theta) + \delta k$. This is the amount that is needed to compensate B for not fighting today and having to arm again, tomorrow, before fighting. Moreover, in the strategy profile, in any subgame in which fighting has not occurred and B is not armed, B will accept an offer that gives them at least $\frac{w(1-\theta)}{1-\delta} - \frac{\delta s(1-\theta)}{1-\delta} + \delta k$ and if the game reaches the next period they will arm. The strategy for A is that they offer the share $1 - (1 - s)(1 - \theta)$ to B if B has armed in the current period, and offer the share

$$\min\{1, max\{0, 1 - [\frac{(1 - w)(1 - \theta)}{1 - \delta} - \frac{\delta(1 - s)(1 - \theta)}{1 - \delta}]\}\}$$

to B if B has not armed in the current period. These strategies are particularly simple as they are stationary. This strategy profile results in game ending conflict in period 1 if and only if the set of offers an armed B is willing to take does not include the one that A is making,

$$1 - (1 - s)(1 - \theta) < s(1 - \theta) + \delta k.$$

[6]This is not the only equilibrium to this game.

This condition simplifies to

$$\delta \geq \frac{\theta}{k}.$$

If this inequality holds, we then need to show that there is a stationary subgame perfect Nash equilibrium with the war by the costly peace effect. To analyze equilibrium strategies, we have to focus on only a small number of classes of subgames. First, consider a subgame in which A has to make an offer. Consider first a subgame in which B has just armed. Using the one-shot-deviation principle, we can rely on the fact that in the next period B will arm and conflict will happen independent of what happens in the current period. So A is not willing to make an offer that will be accepted unless it provides them at least as much as their war payoff from fighting an armed B for 1 period, $(1-s)(1-\theta)$. Thus, the most that A is willing to offer B (if it will be accepted) is $1-(1-s)(1-\theta)$. This is the offer we specified above. Now, if B has not armed, then A has an incentive to induce conflict in the current period, obtaining the higher war payoff from fighting an unarmed B. Thus, the share that A needs to keep in order to prefer acceptance to war is, $x = \frac{(1-w)(1-\theta)}{1-\delta} - \frac{\delta(1-s)(1-\theta)}{1-\delta}$. Therefore, if these offers are within the interval $[0,1]$ then A offers $1 - [\frac{(1-w)(1-\theta)}{1-\delta} - \frac{\delta(1-s)(1-\theta)}{1-\delta}]$ to B at these subgames as specified above.

Now consider B's actions. In a subgame in which B has not armed, the difference in flow payoffs from obtaining the lower war continuation payoff now is $\frac{w(1-\theta)}{1-\delta}$, and arming tomorrow and then receiving the higher war payoff is the difference specified above. Thus, this is the minimal offer B will accept in this subgame. Ignoring the boundary conditions on A's offer, we can express the sufficient condition for A's offer to not be high enough for B to accept:

$$\frac{w(1-\theta)}{1-\delta} - \frac{\delta s(1-\theta)}{1-\delta} + \delta k > 1 - [\frac{(1-w)(1-\theta)}{1-\delta} - \frac{\delta(1-s)(1-\theta)}{1-\delta}]$$

This inequality simplifies to our equilibrium condition $\delta > \frac{\theta}{k}$.

Now consider the decision by B if they have armed. The choice is between obtaining the share offered by A and then paying δk in the next period to obtain the war payoff in the next period, or obtaining the war payoff in the current period. This is the comparison that yields the minimum payoff B will accept described above. We must also check whether B wishes to deviate at the beginning of any period. The payoff they can obtain from not arming and then both players following the strategy profile is $\frac{w(1-\theta)}{1-\delta}$. Arming and then both players following the strategy profile yields the payoff $\frac{s(1-\theta)}{1-\delta} - k$. This is true for any $\delta \in [0,1)$ by Assumption 1.

Thus, we have the following proposition.

Proposition 3 (Costly Peace). *If $\delta > \frac{\theta}{k}$ there is a stationary subgame perfect equilibrium in which B arms in the first period and the players fight in the first period.*

This description is a standard result in the literature on costly peace. Fearon (2018) studied a repeated game in which two countries simultaneously arm to improve their bargaining leverage over an issue. Separately, the two countries may go to war and fight one another for territory. He demonstrates, if countries are sufficiently patient then without fighting, countries could achieve cooperative equilibria with lower spending on arms than the one-shot game. It is the existence of the potential for a fight that can end the interaction that is necessary to generate war. Krainin and Wiseman (2016) present the strongest theoretical result in favor of the costly peace argument. They study a model where a network of countries may make peaceful transfers to one another or fight to disarm their rival permanently and extract their resources forever. They show that when countries are sufficiently patient, all states in the system will fight until only one state remains. Wiseman (2017) extends the arguments to firms in oligopolistic competition and demonstrates that sufficiently patient firms may prefer to initiate price wars that eliminate competition in the long-run than engage in collusive practices. Such an effect can also arise when peace induces costly competition for diplomatic influence and the ability to set the agenda (Ruggiero 2024).

3.3 Secret Arming followed by Bargaining

We now turn to the situation where the militarization decision of B is not observed by A. This leads to a special case of the model in Meirowitz et al. (2022).

In any equilibrium of a game where B can arm, but the arming decision is not observed by A, A's conjecture regarding the strategy that B employs must be correct. Meirowitz and Sartori (2008) show that this hidden-action environment leads to the emergence of strategic uncertainty, where B employs a mixed, rather than pure, strategy in their arming decision. They show that this endogenous uncertainty is closely linked to the probability of war in bargaining. If there is a positive probability of arming, then there must also be a positive probability of war.

The logic for this result is straightforward. If B is arming in an equilibrium in which there is no chance of war, then a deviation to the strategy of not arming, but otherwise playing the same strategy would save the cost k, and not be detected by A. This is a profitable deviation. Consequently, the risk of fighting is a necessary form of discipline to support arming when militarization is a hidden action.

As in the previous model, only two possible offers are sequentially rational for A; the offer that makes an armed player B just indifferent between fighting and accepting and the offer that makes an unarmed player B just indifferent. Therefore, in this model, a risk of war requires that A sometimes make the offer that only the unarmed player B will accept and that B sometimes arms. We see then that war is only an equilibrium phenomenon if both countries employ mixed strategies; there must be uncertainty about B's militarization choice, and there must be uncertainty about A's behavior at the bargaining table.

To characterize such an equilibrium, we need two indifference conditions. First, suppose that B arms with probability q and A makes the offer giving B $(1-\theta)w$ with probability r and $(1-\theta)s$ with probability $1-r$. The second, conciliatory offer is accepted by B regardless of their arming choice, and the aggressive offer is accepted only if B has not armed. This leads to the indifference condition for A

$$1-(1-\theta)s = (1-q)(1-(1-\theta)w) + q(1-\theta)(1-s).$$

Additionally, in order for B to be indifferent, we have

$$(1-\theta)s - k = (1-r)(1-\theta)s + r(1-\theta)w.$$

This leads to the following result.

Proposition 4. *Suppose Assumption 1 is satisfied, then the equilibrium is unique. In equilibrium B arms with probability,*

$$q = \frac{(1-\theta)(s-w)}{\theta+(1-\theta)(s-w)},$$

A makes the offer $(1-(1-\theta)w, (1-\theta)w)$ with probability r, and the offer $(1-(1-\theta)s, (1-\theta)s)$ with probability $1-r$, with

$$r = \frac{k}{(1-\theta)(s-w)}.$$

An unarmed B accepts either offer, and an armed B accepts only the larger offer.

Importantly, this equilibrium assigns positive probability to the three different paths in the baseline deterrent result of Proposition 1.

4 Two-sided arming

Until now, we have focused on the case where only one country, B, can choose to arm or not. Now we explore the case where both countries can arm simultaneously and then bargain.[7] If the countries are mismatched, then the war payoffs are $s(1-\theta)$ for the stronger state and $(1-s)(1-\theta)$ for the weaker state. If they both have the same level of militarization, then the war payoffs are simply $\frac{1}{2}(1-\theta)$ for each state.

In this symmetric setting, it makes sense to have a symmetric bargaining protocol. We consider symmetric Nash demand bargaining (also sometimes called the $\frac{1}{2}$- double auction). In this bargaining game, each side makes a demand x_i. If the two demands sum to less than one, they are compatible with an efficient division of the prize and Country i obtains $x_i + \frac{1-(x_A+x_B)}{2}$. If the demands exceed the size of the pie, then they fight and obtain their war payoffs.

In the spirit of Assumption 1, we make a similar assumption that arming is worthwhile. Specifically, if a country knows it is going to war, then it would rather arm against its opponent than to fight an evenly matched conflict.

Assumption 2. *For both states, the cost of arming satisfies*

$$(1-\theta)(s-\frac{1}{2}) \geq k$$

This assumption also is sufficient for a state to want to arm against an armed opponent and, when that is true, implies Assumption 1.

4.1 Simultaneous public arming with bargaining.

We first consider the case where the arming decisions are observed before bargaining. In the bargaining game, there are many potential equilibrium outcomes. Given the symmetric nature of the game, we will focus on the equilibrium where the surplus is split evenly. This means that in a peaceful settlement, each country will demand and receive their war payoff plus half the surplus.

First, we show that there is a subgame perfect equilibrium in which both countries arm.

Proposition 5. *Assume that Assumption 2 holds. Then there exists a subgame perfect equilibrium where both countries arm and there is a peaceful settlement at*

$$x_A^* = x_B^* = 1/2.$$

[7] Another literature on multilateral military spending looks at the general equilibrium effect of military spending on national wealth (Garfinkel 1990). This literature is related and ties state's arming decisions to tribute, but doesn't speak to bargaining or the onset of war.

	Arm	Not Arm
Arm	$1/2(1-\theta)+\theta/2-k$ $1/2(1-\theta)+\theta/2-k$	$s(1-\theta)+\theta/2-k$ $(1-s)(1-\theta)+\theta/2$
Not Arm	$(1-s)(1-\theta)+\theta/2$ $s(1-\theta)+\theta/2-k$	$1/2(1-\theta)+\theta/2$ $1/2(1-\theta)+\theta/2$

Table 1. Payoff to the bargaining game as a result of arming strategies

To see why this is the case, suppose both countries arm and in every bargaining subgame demand their war payoff (net of arming costs) plus $\theta/2$, given arming strategies. Payoffs to arming strategies in such an equilibrium are described as in Table 1. Payoffs from the split-the-surplus settlement, given that both arm, are

$$1/2(1-\theta)+\theta/2-k.$$

If a country deviates to not arming they get

$$(1-s)(1-\theta)+\theta/2,$$

which is not a profitable deviation if and only

$$1/2(1-\theta)+\theta/2-k \geq (1-s)(1-\theta)+\theta/2$$
$$s-\frac{1}{2} \geq \frac{k}{(1-\theta)}.$$

Last, observe that no country can demand more in any bargaining subgame without inducing war, which is strictly worse than the settlement.

Are there any other equilibrium arming strategies given the play in the bargaining subgames? By Assumption 2 we know that both countries would prefer to arm given the other has not, so there is no equilibrium where both don't arm. It is equally easy to show that it is worse to be unarmed versus an armed opponent than to be their equal. Therefore, in the equilibrium where Nash demand bargaining splits the surplus from avoiding war in every subgame, arming is a dominant strategy.

The equilibrium characterized in Proposition 5 is not unique, but it is perhaps natural, as it is fair and symmetric in this symmetric game. A continuum of other equilibria that are equally efficient can be found by focusing on uneven splits of the surplus. Note, however, that if the split of the surplus depends on arming choices, other equilibrium paths of play may be supportable.

The problem of two-sided arming and bargaining is studied in detail in Jackson and

	H	M	L
H	1/2 1/2	s $1-s$	S 1-S
M	$1-s$ s	1/2 1/2	w $1-w$
L	$1-S$ S	$1-w$ w	1/2 1/2

Table 2. Expected probability of winning a war with three arming levels

Morelli (2009). Their model adds some additional complications. Their analysis shows that it can be in countries' interests to invest in levels of arms purely for deterrence. They argue that focusing on only two levels of militarization obscures this important fact, and they show that even if just three levels are possible, there can exist mixed strategy equilibria in which countries randomize over three levels of arms. Connecting with terms frequently used in the literature, they call these levels dove levels, hawk levels, and deterrent levels. Dove levels are low levels of arms which can be attacked and never deliberately choose to attack. Deterrent levels are those which are not attacked by some types of hawks, and are not the best responses to lower levels of arms. Hawkish arming levels are those which are never attacked and will sometimes attack.[8] Like our example, with binary levels of arms, the possibility of bargaining ensures that countries will not arm themselves to deterrent levels and doves will prefer to just pay off hawks. Interestingly, in their model, war occurs with positive probability even though military investments are public.

To illustrate this logic, consider a model like the one above, with minor changes. Suppose that instead of choosing to arm or not, countries can choose three different investments in arms, $\{L, M, H\}$. As before, assume that if fighting occurs, a fraction θ of the pie is lost. Furthermore, assume that the cost of high levels of arming, H, is $2k$ and the cost of deterrent arming, M, is k, and the cost of dovish arming, L, is 0. We assume $(1-\theta)w < (1-\theta)s < \frac{1}{2}$. Finally, assume that the probability of winning the pie remaining after conflict from each arming profile of arming (s_A, s_B) is given by Table 2.

For simplicity, we focus on the case where there is no bargaining. Rather than the Nash demand game, suppose now that each country simple decides to arm and then after the arming levels are observed, each country decides whether to fight or not. If either side selects to fight, then war occurs. To maintain symmetry, assume that the share of the pie

[8]Note that deterrent and hawk levels of arms need not be mutually exclusive, implying that there may exist equilibria in which countries arm themselves primarily to deter hawks, but are willing to fight certain levels of dove armaments.

going to each player is $\frac{1}{2}$ in a peaceful settlement.[9]

The key insights can be seen if we focus on just finding a symmetric completely mixed strategy equilibrium of this game? Let λ denote the probability of selecting L and μ the probability of selecting M, with the remaining probability going to H. In particular, we focus on a symmetric equilibrium in which each militarization level is played with strictly positive probability and war occurs at the pairs (H, L) and (L, H).

In such an equilibrium, the indifference conditions required in equilibrium are

$$(1-\lambda-\mu)(1-\theta)(1-S)+(\lambda+\mu)\frac{1}{2}=\frac{1}{2}-k$$

$$\lambda(1-\theta)S+(1-\lambda)\frac{1}{2}-2k=\frac{1}{2}-k.$$

The second equation simplifies to

$$\lambda^*=\frac{k}{S(1-\theta)-\frac{1}{2}}.$$

substituting this into the first condition, we obtain

$$\mu^*=(\frac{k}{S(1-\theta)-\frac{1}{2}})(\frac{(1-\theta)(1-S)-\frac{1}{2}}{\frac{1}{2}-(1-\theta)(1-S)})-\frac{(1-\theta)(1-S)+k-\frac{1}{2}}{\frac{1}{2}-(1-\theta)(1-S)}.$$

We may now state a version of Proposition 1 in Jackson and Morelli for our model.

Proposition 6. *In the game with simultaneous arming with three levels and no bargaining, if* $(1-\theta)S-2k>\frac{1}{2}$ *then in the unique equilibrium with weakly undominated strategies at the war stage, war occurs with positive probability (in pairs* (H, L) *and* (L, H)*) and each armament level is chosen with strictly positive probability. The equilibrium mixtures are given by* λ^* *and* μ^* *above.*

While a full proof can be constructed by applying the logic in Jackson and Morelli, here we flesh out the intuition for why a peaceful equilibrium cannot obtain. The parameter assumptions from the first condition imply that from a peaceful profile at (L, L) unilaterally selecting H and fighting is a profitable deviation. So we cannot have a peaceful equilibrium in which both states select L. But from a peaceful profile at (H, H), the last condition indicates that a unilateral deviation to M would save k and still deter fight-

[9]Jackson and Morelli (2009) assume war decisions are sequential, this helps establish the equilibrium is unique. To maintain the symmetry of the game, we may assume that the war decisions are simultaneous and ignore profiles that involve weakly dominated play at the war stage.

ing. From a peaceful profile at (M, M) the second condition indicates that a unilateral deviation to L would save k and still deter fighting. Thus, none of the symmetric profiles can support peace. Can an asymmetric profile support peace? Again, the answer is no because whoever is spending more could deviate to the arming choice of the other player and save at lease k and obtain deterrence. This means we must have mixing, and we must have a risk of conflict. In the paper, bargaining with the possibility of non-binding offers is considered, and this result is shown to carry over to the three-level case

4.2 Simultaneous hidden arming with bargaining.

Next, we consider the case where the two countries can arm and then bargain, but the arming actions are unobserved. We will continue to assume that two evenly matched countries win the war with probability $1/2$ each and, when countries are unmatched in arms, the advantaged country wins with probability $s > 1/2$ and the disadvantaged country wins with the complementary probability $1 - s$.[10]

Here we maintain Assumption 1 and in fact we strengthen it to

Assumption 3. *The payoff from fighting an imbalanced war while armed is sufficiently high, namely*

$$s(1-\theta) \geq \frac{1}{2}$$

After militarization decisions have been made, countries attempt to negotiate a peaceful agreement and avoid a destructive war. Like in the previous section, we represent negotiations as a Nash demand game. Players simultaneously make demands x_A and x_B both in $[0, 1]$. If $x_A + x_B \leq 1$, then each player i receives a split of the pie equal to its demand x_i plus half the surplus $1 - x_A - x_B$. If the demands x_A and x_B are incompatible, i.e., if $x_A + x_B > 1$, then the outcome is war.

To make the exposition parsimonious, we will focus on symmetric arming strategies and introduce the parameter $\gamma = (s(1-\theta) - 1/2)/(1/2 - (1-\theta)/2)$, which subsumes the two parameters θ and s. The numerator of γ is the gain of an armed country from waging war against an unarmed country instead of accepting the equal split. The denominator is the loss from waging war against an armed country rather than accepting the equal split. So, γ represents the ratio of benefits over cost of war for an armed country.

We follow Meirowitz et al. (2019) and select equilibria in which bargaining behavior maximizes the probability of peace (among equilibrium strategies) given the equilibrium probability of arming. We begin our analysis by solving for mutual best responses at the

[10] This section is based on one variant of the model in Meirowitz et al. (2019).

negotiations stage, after militarization decisions have been made. That is, we solve the Nash demand game holding the militarization probability q fixed.

As a function of q, Proposition 7 reports the equilibrium of the Nash demand game that maximizes the probability $V(q)$ of peaceful resolution of the dispute as in Meirowitz et al. (2019).

Proposition 7. *As a function of the arming probability, q, the equilibrium of the Nash demand game that maximizes the peace probability is as follows: For $q \geq \gamma/(\gamma+1)$, the countries always achieve peace by playing $x_A = x_B = 1/2$. For $\gamma/(\gamma+1) > q \geq \gamma/(\gamma+2)$, peace is achieved unless both countries arm; armed countries demand $x_H \in [s(1-\theta), 1-(1-s)(1-\theta)]$ and unarmed countries demand $x_L = 1 - x_H$. For $q < \gamma/(\gamma+2)$, peace is achieved only if both countries are unarmed, unarmed countries demand $x_L = 1/2$, whereas armed countries trigger war by demanding $x_H > 1/2$.*

Meirowitz et al. (2019) show that equilibrium bargaining varies as countries' expectations about arming change. The relevant cut-off values for q are $\gamma/(\gamma+1)$ and $\gamma/(\gamma+2)$. For $q \geq \gamma/(\gamma+2)$ both countries are cautious because the probability their opponent armed is high. Since war with an armed opponent gives a payoff of $(1-\theta)/2$ both countries are willing to choose a settlement that splits the prize and results in a peaceful settlement. On the other hand, when $\gamma/(\gamma+2) \leq q \leq \gamma/(\gamma+1)$ armed countries are willing to risk war, making higher demands, while unarmed countries, fearing war, make low demands that will placate an armed adversary. If $q < \gamma/(\gamma+2)$, however, even unarmed countries make higher demands that trigger war with armed opponents, but result in peace if their opponent is unarmed.

Given these results, and their implications for the consequences of arming strategies, a cost k, Proposition 8 describes the equilibrium strategies that maximize the countries' welfare.

To focus on the clearest case, Meirowitz et al. (2019) make the following assumption.

Assumption 4. $k \geq \underline{k} \equiv \theta\gamma/2 \cdot \gamma/(\gamma+1)$ *and* $k \leq \overline{k} \equiv \theta\gamma/2 \cdot (\gamma+1)/(\gamma+2)$.

Proposition 8. *When the cost of arming, $k \in [\underline{k}, \overline{k}]$, the equilibrium of the militarization and negotiation game that maximizes the players' welfare W is such that each player militarizes with probability $q(k) = \gamma - 2k/\theta \in [\gamma/(\gamma+2), \gamma/(\gamma+1)]$, strong players demand $x_H = s(1-\theta)$, weak players demand $x_L = 1 - s(1-\theta)$, and war breaks out if and only if both players are strong.*

We do not reproduce the proof from Meirowitz et al. (2019) here. For completeness, however, it is worth presenting an overview of the logic behind this result.

The argument can be taken in two steps. First, when the arming cost k lies between $\underline{k}$ and $\overline{k}$, there is an equilibrium of the game in which countries arm with probability $q(k)$, armed countries make a high demand $x_H = s(1-\theta)$ when bargaining, unarmed countries demand $x_L = 1 - s(1-\theta)$, and war breaks out if and only if both countries arm. So, when the militarization cost k is neither too small, nor too large, countries are willing to randomize their arming decision at 'intermediate' values. This is the range in the previous result. At the negotiation stage, the strategies of this equilibrium are consistent with the equilibrium selected by Proposition 7. Hence, as a function of q, this equilibrium maximizes the peace probability at the negotiation stage for each value of q.

The second step involves showing that there cannot exist any other equilibrium with a smaller militarization probability. Notice that the equilibrium of Proposition 8 yields the highest possible payoffs to unarmed countries, the lowest payoffs to armed countries and, therefore, the lowest *ex-ante* incentives to militarize. Because the equilibrium of Proposition 8 minimizes the arming probability q at the militarization stage, and maximizes the peace probability in the ensuing negotiation stage, it immediately follows that it maximizes welfare in the whole game.

Meirowitz et al. (2019) analyze this game as part of a larger exercise to understand whether mediated cheap talk can outperform a variant of this game with cheap talk. The answer is yes, and perhaps most interestingly, they show that a mediator that is mandated only to minimize the odds of war for a current conflict (that is they take q as exogenous) will act in ways that also minimize the incentives to arm. In other words, solving the short run problem that takes arming choices as given happens to solve the long-run problem in which militarization is endogenous.

We see here that while arming can play a role in deterring conflict, unobservable arming and two-sided arming with several levels can lead to war. The first fact is consistent with our existing understanding of the effects of uncertainty on the risk of conflict. The second, that multiple levels of arming can lead to war, is counterintuitive and suggests that policies, like open skies, that allow arming to be observed, may not be sufficient to prevent war.

5 Signaling strength and costs and types with bargaining

Several scholars have developed accounts of militarization as a possible signal about a country's willingness to fight to change the status quo distribution of rents, whether from policy or territorial control e.g. Arena and Wolford (2012). The common components in these models are that one country can arm and some component of the arming country's payoff is private information. After observing the decision whether or how much to arm, the rival country can draw inferences about the rival's type, update its beliefs, and then decide whether to stand firm and fight or concede to a demand. [11]

Slantchev (2005) studies a signaling model in which the signal is made by arming and the costs of mobilization are sunk. The article has several results, but one key finding relates to how signaling through arming affects the probability of war.

To see how this works, we consider a variant of the baseline model with private information. Suppose state B has two potential values for an indivisible good, $t_B \in \{v_B, V_B\}$, each with equal probability. The good has value 1 to state A. Also assume that $v_B < 1 < V_B$ so the efficient allocation gives the high-value type of B the prize, but A keeping the prize when B has low value is socially optimal. Finally, assume that A receives utility of U_A even if they forfeit the good, and prefers capitulating to fighting an armed opponent. That is,

Assumption 5.

$$\min\{(1-w)(1-\theta), \frac{1+(1-s)(1-\theta)}{2}\} > U_A > (1-s)(1-\theta).$$

At the beginning of the game, nature determines B's valuation of the good. After this, B chooses to arm or not. Arming changes A's probability of winning a conflict for the prize to $1-s$ from $1-w$. Upon seeing the arming choice of B, A decides whether to capitulate and give the good to B or call B's bluff and force B to choose to fight or back down. At that point, B chooses to fight or back down. Backing down yields a payoff of 0 to B if they have not armed. If B armed and backs down, then their payoff is $-k$.

Here, arming serves two purposes, it signals the intensity of B's interest and affects the payoff to war directly.[12] Arming can benefit B even if they have a low valuation. Specifically, we assume that

Assumption 6.

$$v_B - k > 0 > (1-\theta)sv_B - k.$$

So if A capitulates after B arms, then the arming choice was worthwhile for B, but

[11] Note that states need not have their investment in arming succeed in improving their probability of victory to signal successfully. Early models of signaling in conflict demonstrated that simply burning money could be used to signal a state's willingness to fight over a good or issue (Fearon 1997). However, later scholars pointed out that military mobilization is a form of sunk cost investment that states make in diplomatic crises and that pure money burning is rare (Slantchev 2005).

[12] Below we discuss the implications of turning off this second channel.

even when strong, the type of B with the lower valuation prefers not to fight. Finally, we impose a restriction that is complimentary to Assumption 5.

Assumption 7.

$$V_B(1-\theta)(s-w) > k.$$

There exist values of k that jointly satisfy these two assumptions when $(V_B - v_B)/V_B > w/s$. Because B is willing to arm to get the prize, there is no separating equilibrium where the high-value type arms and the low-value type does not. Our goal is to demonstrate the possibility of a semi-separating equilibrium in which arming serves as a partially informative signal to A of B's resolve, or value of the prize.

Proposition 9. *Given the assumptions of the signaling game, there exists a perfect Bayesian equilibrium where the high-value type of B arms with probability one, the low-value type mixes between arming and not, state A mixes between calling B's bluff, high-value types fight with probability one and armed low-value types back down.*

To see that this is an equilibrium, start by observing that the high-value type of B prefers to arm and fight by assumption. A is willing to mix and call B's bluff with positive probability, given interim belief $\mu = Pr(t_B = V_B|\sigma(t_b))$, when:

$$U_A = \mu(1-s)(1-\theta) + (1-\mu)$$
$$\mu^* = \frac{1-U_A}{1-(1-s)(1-\theta)}$$

which is between 0 and 1 by Assumption 5. By Bayes rule, the arming strategy for the low-value type must be,

$$q^*(v_b) = \frac{U_A - (1-s)(1-\theta)}{1-U_A}.$$

The value of $q^*(v_b)$ is between zero and one when Assumption 5 is satisfied.

Next, let π^* be the probability that A capitulates to B after B has armed. Given μ^*, π^* must make the low-type of state B indifferent between arming and not. Since after arming, a challenged B backs down, we need A to mix with probability, π satisfying the indifference condition,

$$\pi(v_B - k) + (1-\pi)(-k) = 0$$
$$\pi^* = k/v_b$$

which is between zero and one by the assumptions above.

Several features are worth noting. First, arming can act as a sunk cost signal, like building arms or mobilizing troops. As in typical cases of such signaling under incomplete information, several inefficiencies arise. Sometimes Country A and Country B fight because A is unsure if B is truly the high-value type, or simply bluffing. Low-value types of Country B waste resources arming for conflicts they never intend to participate in, and sometimes Country A concedes the prize to B even when the efficient outcome is not to do so.

In this model, arming has a direct effect on the likelihood of victory in conflict, and it has a signaling effect in this semi-separating equilibrium. If we negate the direct effect, then in order for A to be indifferent between capitulating and not, they need to think it is more likely that B is the type that will not back down.[13] In such a case, the analogue to $q^*(v_B)$ is smaller, meaning that the low-value type arms with a lower probability, and with lower probability, the prize is inefficiently allocated to B, when it is socially optimal to allocate it to A.

5.1 Robustness of the Signaling Result

Several scholars have demonstrated that the existence of signaling equilibria and the comparative statics arising from signaling models are sensitive to assumptions about the source of uncertainty (Arena 2013; Carroll and Pond 2021; Reich 2023), game form (Wolton 2023), and assumptions regarding signaling costs (Reich 2023). For example, Reich (2023) demonstrates that if there is uncertainty regarding a country's initial strength, then weaker states can actually arm more. This is because stronger states are more tolerant of war than their weaker counterparts. Consequently, arming is indicative that the state is a low type.

To see how this works, consider a similar signaling game as before, but in which Country B has private information regarding its probability of winning a war. In this simplified version of Reich (2023), assume that Country B can now be one of two possible types $t_B \in \{L, H\}$, each with equal probability, where the low type's probability of winning a war is given by $\underline{s}$ if it armed and $\underline{w}$ if it is not. Similarly, the high type's probability of winning is given by $\bar{s}$ if it is armed and $\bar{w}$ if it is not. To have these types reflect uncertainty about a country's initial strength, we will have $\underline{w} < \bar{w}$ and $\underline{s} < \bar{s}$. For simplicity's sake, we will assume that arming increases each Country's probability of winning by the same

[13]This argument requires an assumption parallel to Assumption 5 that A prefers capitulating to fighting for sure.

amount, regardless of its type.

Assumption 8.

$$\bar{s} - \bar{w} = \underline{s} - \underline{w}$$

Moreover, we will assume that Country A would always prefer to concede to an armed type of Country B, would strictly prefer to fight an unarmed low type but would strictly prefer to concede in response to an unarmed high type. Let U_A denote Country A's utility from conceding. Formally, these assumptions can be written as

Assumption 9.

$$(1 - \underline{w})(1 - \theta) > U_A > \{(1 - \underline{s})(1 - \theta), (1 - \bar{w})(1 - \theta)\}$$

As before, Assumption 1 will still hold and ensure that Country B will always find it worthwhile to arm if it expects a fight.

Once again, there exists a semi-separating equilibrium. However, this time it is the high types who do not arm.

Proposition 10. *Given the assumptions of the signaling game, there exists a Perfect Bayesian equilibrium where the high type of B never arms, and the low-value type mixes between arming and not, Country A always concedes in response to arming, Country A mixes between calling B's bluff when it is unarmed, and unarmed Country B always fights if Country A does not concede.*

We now construct such an equilibrium. Let π denote the probability that Country A concedes if Country B does not arm. The low type of Country B will be indifferent between arming whenever

$$\pi + (1 - \pi)(\underline{w})(1 - \theta) = 1 - k$$

yielding the critical value

$$\pi(\underline{w}) = \frac{1 - \underline{w}(1 - \theta) - k}{1 - \underline{w}(1 - \theta).}$$

Similarly, the high type of Country B will be indifferent between fighting and not when

$$\pi(\bar{w}) = \frac{1 - \bar{w}(1 - \theta) - k}{1 - \bar{w}(1 - \theta)}.$$

It is straightforward to see that $\pi(\bar{w}) < \pi(\underline{w})$, implying that the probability of concession that makes the high type of Country B indifferent between arming and not is strictly smaller than the probability that makes the low type of Country B indifferent. This reflects the high type's increased tolerance for fighting.

All that is needed to complete the construction of the equilibrium is to find the probability with which a low type of Country B can arm that leaves Country A indifferent between calling B's bluff or not in response to no arming. Formally, this requires that

$$U_A = \mu(1-\bar{w})(1-\theta) + (1-\mu)((1-\underline{w})(1-\theta))$$

so that Country A's belief that Country B is the low types is

$$\mu = \frac{(1-\underline{w})(1-\theta) - U_A}{\bar{w} - \underline{w}}(1-\theta)$$

the above value of μ is strictly greater than 0 given our assumption that $(1-\underline{w})(1-\theta) > U_A$. Moreover, it is simple to check that $\mu < 1$ under the assumption that $(1-\bar{w})(1-\theta) < U_A$. Therefore, the low type of Country B simply arms at the probability required to achieve this belief.

There are several models exploring a different set of environments that produce additional interesting and substantive results. For example, Reich (2022) argues that states may signal strength by handicapping, under-utilizing or under-deploying their military strength, to demonstrate their tolerance for fighting while unarmed and in doing so, can communicate strength. Slantchev (2010), demonstrates that when a state's rival can mobilize in response to demands, states may choose to disguise their type to lull them into complacency and then ambush them.

6 Preventive attack of a state that can arm

We close, by moving from models that focus on strategic militarization to models that focus on actions that a state may take in response to militarization by an opponent.

The most well studied of these actions is preventive attack. Scholars of international relations have been increasingly interested in the following type of narrative: On March 20, 2003, the US and a number of its allies invaded Iraq and toppled its dictator Saddam Hussein. Their stated justification for the war was Hussein's ostensible pursuit of weapons of mass destruction (WMDs). Accepting this justification at face value, the attack on Iraq can clearly be understood as a case of preventative war-the US attacked believing that it possessed a clandestine weapons program that had the potential to rapidly alter the balance of power. Moreover, if the US attacked immediately, then it could destroy Iraq's weapons program and preserve the balance of power in its favor. However, after the US completed its occupation of Iraq, it quickly became apparent that contrary to the US's beliefs, Iraq did not have a secret weapons program.

Inspired by these events, several scholars have studied models of arming in which one country can secretly decide whether to arm, the decision to arm produces a noisy signal, and there is a delay between the investment in arming, and its taking effect. This affords the rival an opportunity to launch a preventative war and prevent the arming from taking place. In such models, preventative war results from a commitment problem-if arming shifts power by enough, or for long enough, then one state may not be able to compensate its rival for the anticipated shift in strength (Powell 2006). Of course, thinking through this logic requires clarity on what kinds of settlement are credible and how long agreements are enforced.

To provide some traction on this intuition, we present the following canonical two period-model from Debs and Monteiro (2014). In period one, Country B makes an unobserved binary arming decision. It may arm at cost k. Though Country A does not observe Country B's decision, it receives a noisy signal $\omega \in \{0,1\}$. Let $Pr(\omega = 0|m_b = 0) = 1$ and $Pr(\omega = 1|m_b = 1) = z_k$ with $z_k \in (\frac{1}{2}, 1)$. After observing the signal ω, Country A must decide whether it will offer a peaceful division $(x, 1-x)$ (with $x \in [0,1]$) or go to war. If Country B does not accept the peaceful division, then war occurs. If no war occurs and Country B has chosen $m_B = 1$, then its investment becomes common knowledge and Country B's strength increases from w to s in the second period, in which Country A makes a take-it-or-leave-it offer. However, if war occurred in period 1, then Country B remains unarmed regardless of its investment decision and both countries receive their wartime payoffs in both periods.

This game has a unique equilibrium that can be obtained by backwards induction. First, if a war does not occur in the first period and A can infer whether B has armed, then Country A will offer Country B its wartime payoff in the second period. Anticipating that it will receive a larger offer if it is armed in the second period, Country B will be willing to accept an offer smaller than its payoff for fighting while weak in the first period

$$1 - x_a = w(1-\theta) - \delta(s-w)(1-\theta).$$

This offer is the minimum offer that keeps Country B indifferent between fighting unarmed in both periods and accepting $1 - x_a$ in the first period, and $s(1-\theta)$ in the second.

Country B can be thought to take a loss in period A relative to their war payoff because they benefit from avoiding conflict in the initial period to let their investment mature, allowing them to be stronger in period 1. If δ is large or $s - w$ is large relative to w the right-hand side can be negative, capturing the fact that the gain to B from not fighting in the first period in order to capitalize on its investment and extract a larger share tomorrow is considerable. Most work in this literature operates under a form of limited liability, assuming that at any period A can only make offers between 0 and 1. If the right-hand side above is negative and A can make offers that involve keeping more than 1 than A could always extract all the value that B obtains from allowing their investment to payoff. But when x must be in $[0, 1]$ the case of a right-hand side that is negative means that B can protect some rents from investing. We side-step that issue here.

Assumption 10. *Arming does not happen too quickly*

$$\frac{w}{s} \geq \frac{\delta}{1+\delta}$$

This assumption ensures that the right-hand side is non-negative, which fits cases where the return from investment in one period is not too large. Note that when there is no discounting the condition reduces to a requirement that the share justified by B's strength is not doubling as a result of the investment k.

Note that Country B can only benefit from arming if it manages to surprise Country A when it does so. Indeed, if Country A learns that Country B has armed, it can adjust its first-period offer down such that the stream of offers is equivalent to fighting a weak type of Country B for two periods. As a result, if Country B's decision to arm is revealed then Country A offers $1 - x_a$ in period 1, $s(1 - \theta)$ in period 2, Country B accepts both offers, war does not occur, and Country B loses k because of their decision to arm.

Consequently, a necessary condition for Country B to arm is that its decision to do so has a sufficiently high probability of remaining a secret. To keep matters interesting, we will make the following Assumption

Assumption 11. *The cost of arming is low enough to justify the expense*

$$(1 - z_k)\delta(s - w)(1 - \theta) > k$$

This condition closely resembles Assumption 1, but is more restrictive. If this condition does not hold, then Country B can expect a stream of payoffs equal to its payoff of fighting while weak, without recouping k.

If Assumption 11 holds, we cannot have an equilibrium in which B selects to remain unarmed with probability one. If Country B never arms, then Country A would offer $1 - x = w(1 - \theta)$ in which case, Country B has a strictly profitable deviation to arming. Moreover, any equilibrium in which B arms with positive probability must be in mixed strategies. To see why, note that if Country B always armed, then regardless of x Country A would simply offer $1 - x_a$ in the first period, in which case Country B has a profitable deviation to not arm. Therefore, Country B must mix whether it arms or not, and given a signal that $\omega = 0$, Country A must mix over the low offer $1 - x_a$ that only an arming state B would accept and a high offer $1 - x = w(1 - \theta)$ that Country B will accept regardless of its arming decision. If Country B has not armed, and receives the low offer, they will prefer to reject it and go to war since they do not expect a surge in strength in period 2. Therefore, the mechanism by which war occurs in this example is a simple risk-reward trade-off (Slantchev and Tarar 2011).

It is straightforward to characterize the mixed strategy equilibrium. Let r denote the probability with which Country A makes the low offer $1 - x_a$ after seeing $\omega = 0$, and with reciprocal probability makes the offer $1 - x = w(1 - \theta)$. Assume that if the low offer is made and accepted than in the second period the offer $1 - x = s(1 - \theta)$ is made, but if the high offer is made and accepted than the offer $1 - x = w(1 - \theta)$ is made. Further assume that after $\omega = 1$ the low offer is made in the first period and if it is accepted the offer $1 - x = s(1 - \theta)$ is made in the second period. In this case, Country B's expected utility for arming is given by

$$z_k[1 - x_a + \delta s(1 - \theta)] + (1 - z_k)[r(1 - x_a + \delta s(1 - \theta)) + (1 - r)(w(1 - \theta) + \delta s(1 - \theta))] - k$$

and their expected utility for not arming is simply

$$w(1 - \theta) + \delta w(1 - \theta).$$

Following $\omega = 0$ a state B that has not armed might face the offer $1 - x_a$. In equilibrium, they reject this offer and obtains payoff $(1 + \delta)(1 - \theta)w$. If they accept the offer $1 - x_a$ then in the second period, A mistakenly believes B is armed and offers $1 - x = (1 - \theta)w$.[14] This path yields the same payoff as the path from rejecting $1 - x_a$ and thus B's response is sequentially rational at this information set.

To characterize the mixture probabilities, we begin by setting B's expected payoffs from arming and not arming equal to each other, we find that Country A makes the low

[14]In the usage of Acemoglu and Wolitzky (2024), this is a form of misperception, whose broader implications for conflict are considered in their chapter.

offer with probability,

$$r^* = \frac{\delta(1-z_k)(s-w)(1-\theta)-k}{\delta(1-z_k)(s-w)(1-\theta)}$$

Let q denote the probability with which Country B arms. Country A's expected utility for making the low offer, conditional on a signal $\omega = 0$ is given by

$$\frac{q(1-z_k)}{(1-q)+q(1-z_k)}[x_A+\delta(1-s(1-\theta))] + \frac{1-q}{(1-q)+q(1-z_k)}[(1-w)(1-\theta)+\delta(1-w)(1-\theta)]$$

and their expected utility for making the high offer conditional on a signal of $\omega = 0$

$$1-w(1-\theta)+\delta\frac{q(1-z_k)}{(1-q)+q(1-z_k)}(1-s(1-\theta))+\delta\frac{1-q}{(1-q)+q(1-z_k)}(1-w(1-\theta))$$

Setting the two equal to each other, we find that Country B arms with probability

$$q^* = \frac{\theta+\delta\theta}{\delta(1-z_k)(s-w)(1-\theta)+\theta+\delta\theta}$$

We can therefore summarize the result in the following proposition.

Proposition 11. *If Assumption 10 and Assumption 11 hold, then there is a unique equilibrium to the two-period hidden arming game in which Country B arms with probability q^*. If $\omega = 1$, then Country A demands x_A in period 1 and $1-s(1-\theta)$ in period 2 and Country B accepts both demands. If $\omega = 1$ with probability r^* Country A makes the low offer, demanding x_A and demands $1-w(1-\theta)$ with probability $1-r^*$ in period 1. In response, Country B always accepts the demand $1-w(1-\theta)$ in the first period but rejects demand x_A if it has not armed. In the second period, if the low offer was made and accepted then A demands $x = 1-s(1-\theta)$ which is accepted and if the high offer was made and accepted then A demands $x = 1-w(1-\theta)$ which is accepted by a state B that has not armed and rejected by a state B that has armed.*

6.1 Commitment

The model above involves two limits on the offers that A can credibly make. The first constraint that we already discussed is that $x \in [0,1]$. As mentioned, when Assumption is relaxed, the requirement that $x \geq 0$ matters. A second, perhaps more interesting, restriction is the assumption that an offer made by A is only about a share in the immediate period. The offer made in period 2 if war does not occur must be sequentially rational, that is to say, it is an offer A would be willing to make at that point. What, then, would happen if we changed the game so that A makes a pair of initial offers in the first period.

The first is the share of the pie that they will keep in period 1 if war does not occur in period 1 and the second is the share of the pie that they will keep in period 2 if war occurs in neither period. The key here is that we are allowing them to commit to the settlement before they learn ω and before they see how A responded to the initial offer.

A natural question to ask is whether in the model in which A has the ability to commit to transfers over both periods, we can construct an equilibrium in which B does not arm and fighting does not occur. To obtain these efficiency gains, there are two key avenues open to A in the model with commitment. They can commit to offering settlements in period 2 that give B more than its war payoff, and they can commit to offering settlement in period 2 that are sufficiently unattractive that B will reject them even though another offer that has a positive probability of being accepted is more attractive to A at the time. As we show now, the threat of the latter is a sufficient tool to support an efficient equilibrium.

Suppose that if A does not learn that B has armed it makes the first period offer $\hat{x}$ such that $1 - \hat{x} = w(1-\theta)$ and it makes the same offer in the second period. On the other hand, if A learns that B has armed in the first period, it offers $x = 1$ in the first period and $x = 1$ in the second period if that period is reached. Given this commitment, the payoff to B from not arming and making sequentially rational acceptances is

$$U_B = (1+\delta)(1-\theta)w.$$

If B arms then it obtains expected utility

$$U'_B = z_k(1+\delta)(1-\theta)w + (1-z_k)[(1-\theta)w + \delta s(1-\theta)] - k.$$

Under assumption 11 $U'_B > U_B$ indicating that the use of commitment to not make lower offers alone does not support this path. Now suppose that A commits to making a larger than sequentially rational transfer in their period 2 offer after observing $x = 0$. Denote this transfer by t. Assume for now that the transfer is sufficiently small that a player B who has armed would not accept the settlement in period 2. This requires that

$$t \leq (s-w)(1-\theta)$$

In order for the transfer to be sufficient to deter arming, we need $U_B + \delta t \geq U'_B$. Setting these equal, we obtain

$$\delta t = (1-z_k)(1-\theta)\delta(s-w) - k$$

$$t = (1 - z_k)(1 - \theta)(s - w) - \frac{k}{\delta}$$

This value satisfies the inequality above.

The payoff to A is then

$$U_A^C = (1 + \delta)(1 - (1 - \theta)w) - (1 - z_k)(1 - \theta)(s - w) + k$$

It remains to verify that A prefers to consume this path than their equilibrium payoff from the previous section.

In the equilibrium above, with probability rz_k A obtains

$$(1 + \delta)(1 - w(1 - \theta))$$

Following $x = 0$ which occurs with probability $r(1 - z_k) + (1 - r)$ A randomizes, but since they are indifferent, it is sufficient for us to focus on their payoff from the high offer. This offer yields $1 - w(1 - \theta)$ in period 1 and then if B has not armed it yields $\delta(1 - w(1 - \theta))$. But if B has armed then A obtains $\delta(1 - \theta)(1 - s)$. Combining these terms, we obtain the expected payoff to A of

$$U_A = 1 - w(1 - \theta) + \delta[rz_k w(1 - \theta) + r(1 - z_k)(1 - \theta)(1 - s) + (1 - r)(1 - w(1 - \theta))]$$

Comparing U_A^C with U_A is tedious, but it is not difficult to find parameters satisfying Assumptions 10 and 11 that make commitment better. This is true for most of the combinations of the parameters satisfying these assumptions. However, by selecting combinations of the parameters that near the boundary of these conditions, we can find settings where commitment does not help.

6.2 Infinite-Horizon Model

Movement from the two-period model to longer horizon models demonstrates an interesting intuition: if arming shifts power by a sufficiently large amount for long enough, then Country A will go to war to prevent it. Note that it is possible to retain a two period model and capture this intuition by changing the magnitudes of some payoffs, but in the interest of providing a broader perspective on modeling strategies in the literature we chose to present an infinite horizon extension.

Consider the following simplified version of Debs and Montero (2014). In the game, time is indexed by $t = 0, 1, 2, ..., \infty$ and both countries discount the future at a rate δ. In each period, countries play the following stage game. First, Country B gets to choose whether to arm or not at cost k. Country A does not observe Country B's decision. However, if Country B decides to arm, Country A receives a noisy signal $\omega \in \{0, 1\}$ where $Pr(\omega = 0|m_b = 0) = 1$ and that $Pr(\omega = 1|m_b = 1) = z_k$ with $z_k \in (\frac{1}{2}, 1)$. This implies that a signal $\omega = 1$ implies that Country B has chosen to arm, whereas a signal of $\omega = 0$ need not imply that Country B has not armed. After observing the signal ω, Country A must decide whether it will offer a peaceful division $(x, 1 - x)$ or go to war to determine the division for that period. If Country B does not accept the peaceful division, then war occurs. To keep matters simple, assume that if a war occurred, then both countries obtain their wartime payoff forever.

Assume that Country A is willing to launch a preventative war if it were known that Country B is arming and is willing to accept a demand of $x = 1$ in the current period and $1 - s(1 - \theta)$ in every period thereafter, i.e.,

$$\frac{(1-w)(1-\theta)}{1-\delta} > 1 + \delta \frac{1-s(1-\theta)}{1-\delta}$$

This can be simplified in the form of the following assumption

Assumption 12. *Country A is willing to launch a preventative war*

$$(\delta s - w)(1-\theta) > \theta$$

Note, that if this assumption does not hold, then war can still result via a risk-reward trade-off mechanism as it did in the two-period example. Additionally, we will assume that Country B's probability of getting caught while arming is sufficiently low to justify trying to arm,

$$z_k \left(\frac{w(1-\theta)}{1-\delta} \right) + (1 - z_k) \left(\frac{s(1-\theta)}{1-\delta} \right) - k > \frac{w(1-\theta)}{1-\delta}$$

which can be simplified in the following assumption.

Assumption 13. *Country B is willing to risk arming if*

$$(1 - z_k)(s - w)(1 - \theta) > k(1 - \theta).$$

This Assumption is more easily satisfied than Assumption 11 since the cost of arming can be recouped over a larger number of periods. If this assumption does not hold, then the threat of Country B's decision to arm being discovered and preventative war effectively deter Country B from arming.

However, if both assumptions hold, then the game has a stationary mixed strategy equilibrium in which B armes with probability q and A attacks with probability ϵ following a signal of $\omega = 0$ (and attacks with probability 1 following a signal of 1) in every period that is reached. In this case, Country B's expected utility from arming is given by

$$[z_k + (1 - z_k)\epsilon]\frac{w(1-\theta)}{1-\delta} + (1 - z_k)(1 - \epsilon)\left[w(1-\theta) + \delta\frac{s(1-\theta)}{1-\delta}\right] - k$$

and their expected utility for not arming is given by

$$\frac{w(1-\theta)}{1-\delta}.$$

Setting the two equal, we find that Country B will be indifferent between arming and not when Country A responds to a signal ω by going to war with probability

$$\epsilon^* = \frac{\frac{(s-w)(1-\theta)}{1-\delta}\delta(1-z_k) - k}{\frac{(s-w)(1-\theta)}{1-\delta}\delta(1-z_k)}.$$

Similarly, Country A's expected utility from attacking following a signal of $\omega = 0$ is given by

$$\frac{(1-w)(1-\theta)}{1-\delta}$$

and their expected utility from not attacking is given by

$$V(0) = 1 - w(1-\theta) + \delta\frac{q(1-z_k)}{q(1-z_k) + (1-q)}\frac{1 - s(1-\theta)}{1-\delta}$$
$$+\delta\frac{1-r}{q(1-z_k) + (1-r)}\left[qz_k\frac{(1-w)(1-\theta)}{1-\delta} + (1 - rz_k)V(0)\right]$$

simplifying the expression for $V(0)$ and setting the two equations equal to each other, we find that Country A will be indifferent between attacking and not when Country B arms with probability

$$q^* = \frac{\theta}{(1-z_k)(s-w)(1-\theta) + \theta z_k}.$$

We can summarize the result in the following proposition.

Proposition 12. *If Assumptions 12 and 13 hold, then there exists an equilibrium to the infinite-horizon repeated arming game in which Country B arms with probability q^*. If $\omega = 1$ in any period, then Country A goes to war. Otherwise, Country A goes to war with probability ϵ^* and demands $x = 1 - w(1-\theta)$ with probability $1 - \epsilon^*$, which Country B accepts.*

Scholars have added additional features to the above model. For example, Debs and Monteiro (2014) consider an environment in which war is not game ending but instead prevents Country B from arming for N periods, and find that as N increases the probability of preventative wars, including mistakenly launched ones, goes up. Others have sought additional mechanisms with which to explain the Iraq war, particularly why Iraq did not reveal that it had not armed to inspectors. Coe and Vaynman (2020) argue that disclosing information about arming decisions may weaken Country B and cause them to withhold information. Baliga and Sjöström (2008) study a model in which Country A can attack after arming has been realized and Country B has been afforded the opportunity to reveal its arms to explain why Iraq benefited from strategic ambiguity. The key innovation here is to have the arming country potentially be a crazy type, who is more likely to arm and who gives its rival a worse payoff if it is armed. In this case, revealing that one is armed might incentivize an attack because it makes the rival believe that the armed country is a crazy type. On the other hand, revealing that one is unarmed can incentivize an attack.

Some authors have studied a similar problem in which a country can take costly measures to effectively disarm their rivals. Observing that countries often take measures short of preventative wars to prevent their rival's from arming, Schram (2021) studies a model in which countries can decide how much to "hassle" their rival to mitigate an exogenous power increase in the next period. He shows that when such measures are effective and war is costly, a country may repeatedly choose to hassle a rival rather than launch a preventative war. Coe (2018) argues that the US was containing Iraq in this way until a decrease in the efficacy of containment led it to go to war. In a companion paper, Schram (2022) studies a model in which a country can endogenously decide whether and how much to arm and its rival can respond by hassling or launching a preventative war. Surprisingly, he shows that the ability to take actions short of war can actually make the hassling country worse off, since it makes the threat of war less credible and embolden its rival to arm.

7 Conclusion

This review has explored how models of strategic interaction have been used to study militarization decisions and their impact on negotiations and the likelihood of war. Through the development of a baseline model and various extensions, we have highlighted key forces that shape militarization incentives and outcomes.

A core insight is that the ability of states to commit to alternative resource divisions limits inefficient fighting, but opportunities for investment in strength that change war payoffs continue to impact negotiated agreements. When militarization is observable, it can serve as a deterrent. However, when it is unobservable, endogenous uncertainty emerges, increasing the risk of war. Whether arming is framed as a pre-commitment versus a response also matters. If considered a commitment, a state may stand firmer in subsequent bargaining. As a response, sunk costs limit what a state can credibly demand.

Signaling motivations feature prominently in some models. Militarization may signal resolve or strength and deter aggression. However, it can also provoke arms races. Allowing for more than two levels of arms demonstrates possibilities for investing purely to deter the strongest types of opponents. Preemptive attack models underscore risks that incentivize preventative war when power shifts are substantial.

Across models, the probability of war-fighting and the extent of wasteful arming provide natural welfare metrics. Hidden arming and signaling tend to increase conflict odds versus observable decisions. Uncertainty over the costs and benefits of arming for a potential aggressor results in higher expenditures. Allowing states to endogenously choose continuous investment levels mitigates distortions relative to a binary choice.

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