# Costly Signaling, Resolve, and Martial Effectiveness*

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**Abstract**

Costly signaling has become a primary prescription for peace. Yet, as I demonstrate in this paper, costly signaling can only eliminate uncertainty about resolve. When states are uncertain about martial effectiveness, the willingness to employ a costly policy instrument cannot reveal private information. Moreover, when states are uncertain about martial effectiveness, the very instrument best suited to signaling resolve, military preparations, can make war *more* likely rather than less. Once we acknowledge that resolve is not the sole source of uncertainty in international politics, we are forced to conclude both that costly signaling is less relevant than previous studies suggest and that encouraging states to employ policy instruments useful for signaling resolve will at times increase the risk of war.

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If information problems are a primary cause of war, then we might expect information revelation to prevent war. Kydd summarizes this view well: "If uncertainty is at the heart of crises, then communication is the key of resolving them," (Kydd 2005, 186). Scholars have accordingly sought to determine whether and when states can credibly communicate their private information. The primary means by which this is thought to be achieved is through costly signaling,[1] which has essentially become the textbook recommendation for preventing war.[2] However, the efficacy of costly signaling has thus far only been considered in the context of uncertainty over the subjective value an actor ascribes to the disputed good, which is often referred to simply as uncertainty over resolve.[3]

This would not be troubling if costly signaling was equally effective at revealing other types of private information. However, as I demonstrate below, it is not. Specifically, I show that private information about martial effectiveness—or intangible qualities such as unit cohesion, esprit de corps, professionalism, leadership, bravery, ingenuity, and morale that influence how well a fighting force performs on the battlefield—cannot be revealed through costly signaling. Yet if states hold private information about the ability of their militaries to wage war effectively, that necessarily introduces uncertainty over the likely outcome of war and so has much the same effect as uncertainty over relative military capabilities.[4]

[1]Naturally, the most straightforward means of communication between states is diplomacy, but the incentive to misrepresent private information is generally thought to render diplomatic statements meaningless (Fearon 1995). After all, cheap talk reveals information if and only if actors' have common interests (Crawford and Sobel 1982), which states engaged in international crises almost by definition do not. See however, Ramsay (2011) and Sartori (2005). For a discussion of costly signaling outside the context of international conflict, see especially Austen-Smith and Banks (2000) and Austen-Smith (2002).

[2]See Frieden, Lake, and Schultz (2010, 99–105).

[3]The word "resolve" can be interpreted in other ways, and is notoriously difficult to measure empirically. While recognizing these difficulties, I will follow convention and focus on uncertainty over a subjective valuation term, since those actors who ascribe greater value to the good in dispute will accordingly be more willing to bear the costs of war rather than to accept any given peaceful outcome than would actors who ascribe less value to the good, and the willingness to bear costs in pursuit of an objective is one of the more common understandings of "resolve."

[4]One might therefore wonder why it is necessary to distinguish between martial effectiveness and military capabilities. I do so because Slantchev (2005, 2011) persuasively demonstrates that the value each side ascribes to the good in dispute influences the material resources they will marshal in a military contest over said good, thus rendering any distinction between uncertainty over resolve and uncertainty over relative capabilities problematic. It is more difficult, however, to see how the stakes of any given conflict determine the fundamental ability of a nation's military to wage war, given some fixed size and set of equipment.

The intuition here is relatively straightforward. An action cannot reveal information unless it would be more likely to be chosen by those who possess a certain quality than those who do not. Put differently, there must be some disincentive for those who lack said quality to mimic the behavior of those who possess it. As discussed above, when one side is uncertain about the resolve of another, what they question is the value their opponent ascribes to the good in dispute. Those who are relatively high in resolve might well be willing to incur costs they'd eschew if less resolved because, more or less *by definition*, they are willing to incur greater costs in pursuit of their objective. The disincentive for less resolved types, then, comes *from the very fact that they are less resolved*. The story is completely different when one state is uncertain about another's martial effectiveness, however. If it is known that those who send a signal by way of incurring costs will be offered relatively attractive terms compared to those who do not, and the only difference across types is how well they would perform in a war that will not occur in equilibrium, then the costs of sending the signal that induces the more attractive set of terms must either be prohibitive irrespective of type or acceptable irrespective of type. Either way, no information is conveyed.

For example, if those who fail to send a signal are asked to surrender 70% of some disputed territory, while a mere 20% is demanded of those who send the signal, we might well expect that relatively unresolved states will not value the territory enough to incur the costs of sending the signal while a more resolved one would do so. But, holding constant the value of the territory, a state whose military fares poorly on the battlefield is no less likely to pay some fixed cost in order to hold on to that additional 50% of the disputed territory than is a state who would expect to fare better in a war that will never occur.[5]

Of course, one might argue that if states can alleviate *some* uncertainty, that is a good thing. Extant claims about costly signaling might need a small caveat, one might argue, but are there broader implications for the conduct of policy or scholarly inquiry?

[5]This, of course, assumes that the cost of the signal does not depend on martial effectiveness. I will argue below that even if the putative signal comes from decisions over whether to engage in military preparation for war, there is little reason to assume that it would.

Indeed there are. If states are uncertain about martial effectiveness, the very policy instrument that best facilitates the signaling of resolve—namely, military preparation for war (Slantchev 2011)—can prove destabilizing. Attempts at reducing uncertainty may therefore, under certain circumstances, solve one problem but exacerbate another.

When relatively weak defenders ready themselves for war, they potentially move from a position of weakness to one of strength. But in many cases, they either cannot or choose not to achieve anything more than shifting the situation from one of preponderance to one closer to parity. Unfortunately, shifts towards parity exacerbate the problem of uncertainty over martial effectiveness. That is, the challenger faces a greater incentive to risk war when her material capabilities roughly equal those of the defender.[6] This is because the latter's martial effectiveness will have a bigger impact on the terms he expects to accept at the end of any war if the two sides are evenly matched in other respects than would be the case of either side enjoyed a preponderance of capabilities. That is, if *either* side possesses an overwhelming material advantage, the outcome of a military contest is unlikely to depend much on the martial effectiveness of the defender, as it will instead primarily reflect the distribution of capabilities. But when the two sides are evenly matched in other respects, whether the defender's forces are particularly good fighting can make a big difference. Accordingly, when either side possesses a preponderance of capabilities, and there is thus little uncertainty about the likely outcome of war even if there is substantial uncertainty over the defender's martial effectiveness, the challenger has little incentive to issue demands that the defender would accept if and only if his martial effectiveness is sufficiently low. There is simply too little gained by pushing for the best possible deal. But if the two are near parity, the challenger might well risk war because the terms she can get the different types to accept will differ more substantially. Thus, since the defender's willingness to engage in costly military preparations cannot reveal information about his martial effectiveness, if those preparations serve to bring the two sides closer to parity, the effect will be destabilizing.

[6] Throughout, I treat the challenger as female and the defender as male.

That is not to say that it is unwise for weak defenders to prepare for war, of course. A world in which peace is certain to prevail because the defender will have no choice but to concede to the challenger's demand is not necessarily better than one where the defender can expect to retain a considerably greater share of the disputed good, though he will have to fight for it. Put differently, the preceding claim is not intended as a normative argument against military preparation for war. It does, however, mean that we need to consider the possibility that encouraging states to engage in military preparations might mean encouraging them to increase the risk of war. It also means that it is inappropriate to argue, as Slantchev (2011, 5) does, that wars occur when states are unwilling to incur the costs of military mobilization. Such a conclusion would be valid if and only if we assumed that states can observe qualities such as morale, leadership, bravery, and ingenuity, which may be even less observable than resolve and since they concern characteristics of individual soldiers and officers more so than the preferences of those who decide whether to give them marching orders. If states are uncertain about one another's martial effectiveness—as intuition suggests they *must be*, at least to some extent—the effect of military preparation for war will thus depend on the initial distribution of material capabilities. Under certain conditions, then, an unwillingness to incur the costs of military preparations might indeed act to encourage the onset of war, as Slantchev (2011) argues. But that is not a general result. At least some of the time, particularly in cases where the defender is at a material disadvantage vis-a-vis the challenger, his failure to prepare for war will serve to prevent its occurrence.

I proceed in three steps. First, I introduce an ultimatum crisis bargaining model in which the defender has the option of engaging in costly military preparations prior to the challenger issuing her demand. Second, I discuss the effectiveness of military preparations for facilitating costly signaling. Third, I discuss the relationship between military preparations and war when the challenger is uncertain about the defender's martial effectiveness. I conclude with a discussion of the broader implications of this analysis.

# The Model

The model begins with some defender, denoted $D$, choosing either to engage in military preparation or not. This may take the form of mobilizing existing forces, calling up reservists or conscripting civilians, purchasing new armaments, developing new weapons systems, negotiating alliances or assembling ad hoc coalitions.[7]

A richer approach would allow $D$ to decide precisely how much he is willing to prepare for war. However, while extending the model in such a way might yield additional insights, the results obtained under uncertainty over resolve are broadly similar to those of Slantchev (2005, 2011). This suggests that treating military preparation as a binary choice, which greatly simplifies the analysis, is relatively innocuous.

I assume military preparations for war increase the defender's military capabilities, which are denoted $m_D > 0$, but have no effect on the fundamental ability of $D$'s fighting forces to make effective use of said capabilities, or $D$'s martial effectiveness, which I denote $e_D > 0$.[8] More formally, when $D$ engages in military preparations, $m_D$ is multiplied by some constant, $\beta > 1$, but $D$ incurs cost $\kappa > 0$. Note that this is a cost that cannot be recouped if war is averted, unlike the term representing the costs of war that will be introduced below. In this sense, military preparation sinks costs. However, as Slantchev (2005) notes, it also makes resort to war more attractive, and thus does not *merely* sink costs.[9]

[7]Both Fearon (1997) and Slantchev (2011) focus on a narrower set of actions when assessing the military instrument. Neither discusses alliances or coalitions, for example.I therefore focus on the broader concept of military preparation rather than the narrow one of military movement or mobilization. Note, however, that military preparations conducted in secret fall outside the scope of this analysis. See Slantchev (2010) for an explication of why states might do so. Also, while arranging assistance provided by another state will have much the same effect as an increase in one's own capabilities, the politics of alliances and coalitions are obviously different from internal means of preparation. See, inter alia, Wolford (Forthcoming *b*) and Wolford (Forthcoming *a*).

[8]Some aspects of martial effectiveness might well be enhanced by training exercises. However, other aspects are essentially non-manipulable. However, if we broke $e_D$ into separate terms and assumed below that only the portion that deals with the strictly non-manipulable aspects of martial effectiveness was unknown to $C$, rather than all of $e_D$, none of the substantive conclusions would change.

[9]The defender never faces a choice between backing down and standing firm here, as he does in the models analyzed by Fearon (1997) and Slantchev (2005, 2011). The relevant question here isn't whether the defender is willing to fight in some absolute sense, but how far he can be pushed before he does so. It may not be useful then to speak of military preparation as tying $D$'s hands. However, the set of demands $D$ can credibly threaten to reject expands after he engages in military preparation.

After she observes $D$'s decision, the challenger, denoted $C$, either issues a verbal demand for territorial or policy concessions, or executes a *fait accompli*.[10] More formally, $C$ chooses the size of $x \in [0, 1]$, which represents the share of the dispute good (or bundle of goods) that will come under $C$'s control if $D$ chooses not to resist. Should $D$ choose to resist, however, a war occurs. That is, I model crises using the standard ultimatum bargaining protocol.

To be sure, real world crises often do not play out this way. However, there is growing evidence that little is typically gained from allowing for more realistic protocols. For example, Tarar and Leventoğlu (2008) not only allow for alternating offers, as did Powell (1996, 1999), but also for *immediate* counteroffers, which Powell did not. Nonetheless, they conclude that if the actors are sufficiently impatient, war can still occur. More importantly, it occurs primarily because of the familiar risk-return tradeoff, and the relationship between the distribution of capabilities and the status quo distribution of benefits identified by Powell (1996, 1999) remains. Similarly, Fey, Meirowitz, and Ramsay (2013) find that the basic insights of canonical models remain essentially unchanged even if we allow for retractable offers or continued bargaining in lieu of war. Finally, Fey and Ramsay (2011)—who distinguish between uncertainty over resolve and uncertainty over the likely outcome of war, as I do here—demonstrate that the link between uncertainty and war does not depend on any particular assumptions about the bargaining protocol. In short, while allowing for more flexible bargaining protocols might help us if we wish to answer questions pertaining to *when* an agreement will be reached,[11] we have little reason to believe that models employing this simplest of all protocols distort our understanding of *whether* an agreement will be reached in lieu of war, which is the focus of the present study.[12]

[10] Most authors analyzing models similar to the one presented here have described this move simply as a demand or a proposal. However, Fearon (1995) makes a compelling case that in an anarchic system, states can and often do execute *fait accompli*. These can take the form of seizing territory or unilaterally altering their policies in a way that adversely affects others. This is a subtle but important distinction.

[11] For example, if one wishes to study war duration rather than onset, one obviously cannot rely on models in which war is treated as a game-ending costly lottery that takes place the moment one side declines the other's first and only offer. As such, many have analyzed models that treat war as an extension of the bargaining process rather than an alternative to it. See, inter alia, Wagner (2000), Filson and Werner (2002), Slantchev (2003), Smith and Stam (2004), and Powell (2004).

[12] Naturally, more complicated protocols might also be necessary if we sought to better understand the

In the event that the states fail to seize their one and only opportunity to reach an agreement, let $w \in (0, 1)$ denote the share of the dispute good that is expected to come under $C$'s control by war's end. Note that the more common interpretation of such a term (commonly denoted $p$ instead of $w$ for that very reason) is as $C$'s probability of winning full control of the good, since $w(1) + (1 - w)(0) = w$. However, even if the two sides expect to eventually reach an agreement—if it is common knowledge that they will fight what Clausewitz (1976) called a limited war—that agreement is likely to reflect, in large part, the probability that $C$ would have won if the two did fight an absolute war.[13] Thus, we can view $w$ as an expected share of a continuously divisible good rather than a probability of acquiring the totality of the disputed good, and thereby recognize that most wars end with negotiated agreements without explicitly modeling intrawar negotiations.

For the sake of simplicity, I assume that $w$ reflects each sides military capabilities as well as their martial effectiveness, though I recognize that we have considerable evidence that war outcomes depend on a variety of other factors.[14] However, none of the substantive conclusions here depend on this simplification.

More formally, let $wn$ denote $C$'s share when $D$ does not engage in military preparations and $w_m$ when $D$ does, where $w_n \equiv \dfrac{e_C m_C}{e_C m_C + e_D m_D}$ and $w_m \equiv \dfrac{e_C m_C}{e_C m_C + e_D \beta m_D}$. Note that this specification ensures that $w$ is increasing in $C$'s material capabilities ($\dfrac{\partial w}{\partial m_C} > 0$) and $C$'s martial effectiveness ($\dfrac{\partial w}{\partial e_C} > 0$) but decreasing in $D$'s material capabilities ($\dfrac{\partial w}{\partial m_D} < 0$) and $D$'s martial effectiveness ($\dfrac{\partial w}{\partial e_C} < 0$), and that the challenger receives a strictly smaller share of the good when facing a defender who prepared militarily for war than one who did not ($w_n < w_m \Leftrightarrow \beta > 1$). It also assumes that no amount of martial effectiveness will help a state which possesses no material capabilities, and no amount of capabilities will be of use to a completely ineffective army.

distributive character of agreements reached in equilibrium, or if we wished to make fine-grained predictions about how interactions between specific states at specific points in time would unfold. However, few scholars of international relations devote much attention to such questions.

[13] Again, see Wagner (2000) and other studies of intrawar bargaining.

[14] See, inter alia, Stam (1996), Reiter and Stam (1998), and Sullivan (2012).

Note too that while military preparations boost the defender's material capabilities, the benefit thereof is necessarily increasing if $e_D$. Thus, the assumption that the cost of engaging in military preparations is independent of the defender's martial effectiveness is *not* tantamount to assuming that the attractiveness of military preparations is independent of type. It only means that the *cost* of doing so does not depend on $D$'s type—which is easily justified. (Slantchev 2011, 67-75) discusses at length the costs of military preparations. Few of the factors he emphasizes, such as the financial costs of provisioning troops or the opportunity cost of shifting transferring labor and capital away from economically productive activity, could credibly be linked to variation in the bravery of one's soldiers or the quality of the leadership provided by the officers who command them.

Below, I will discuss a version of the model where $D$ knows the exact size of $e_D$ while $C$ only knows that $e_D = \underline{e}_D$ with probability $q_e$ and $e_D = \overline{e}_D$ with probability $1 - q_e$, where $\underline{e}_D < \overline{e}_D$. It will therefore become necessary to distinguish not only between $w_n$ and $w_m$, but between $\underline{w}_n \equiv \dfrac{e_C m_C}{e_C m_C + \overline{e}_D m_D}$, $\overline{w}_n \equiv \dfrac{e_C m_C}{e_C m_C + \underline{e}_D m_D}$, $\underline{w}_m \equiv \dfrac{e_C m_C}{e_C m_C + \overline{e}_D \beta m_D}$, and $\overline{w}_m \equiv \dfrac{e_C m_C}{e_C m_C + \underline{e}_D \beta m_D}$ where $\underline{w} < \overline{w} \Leftrightarrow \underline{e}_D < \overline{e}_D$ indicates, quite intuitively, that $C$ expects to fare better against $D$ when $D$'s forces are less martially effective, irrespective of whether $D$ did or did not prepare for war militarily.

Of course, forcing $e_D$ to take on but one of two possible values is a simplification. However, allowing $e_D$ to vary continuously would complicate the analysis considerably, and it would do so without much altering the substantive implications. If I were to allow $e_D$ to vary continuously, then instead of discussing whether certain factors that encourage $C$ to risk war or not, I would discuss how those factors increase the probability of war induced by $C$'s optimal proposal, which would always be greater than zero.

Similarly, when introducing uncertainty over $D$'s resolve, I will assume that $C$ knows $D$ must be one of two possible types. More formally, the players' utility for any given outcome is assumed to depend not only on the distributional outcome, or their respective share of the disputed good in an objective sense—$x$ for $C$ and $1 - x$ for $D$ if the game ends peacefully;

$w$ for $C$ and $1-w$ for $D$ if it ends in war—but also the subjective value they ascribe to the good in dispute, denote $\nu_C > 0$ for $C$ and $\nu_D > 0$ for $D$, as well as the costs incurred in war, denoted $c_C \in (0,1]$ for $C$ and $c_D \in (0,1]$ for $D$. When $C$ is assumed to be uncertain about $D$'s resolve, I will assume that $D$ knows the exact size of $\nu_D$ while $C$ knows only that $\nu_D = \underline{\nu}_D$ with probability $q_\nu$ and $\nu_D = \overline{\nu}_D$ with probability $1-q_\nu$, where $\underline{\nu}_D < \overline{\nu}_D$.

Putting everything together, if $D$ does not engage in military preparation and allows $C$ to acquire $x$, $C$ receives $\nu_C x$ while $D$ receives $\nu_D(1-x)$. If $D$ does not engage in military preparation yet nonetheless refuses to allow $C$ to acquire $x$, then $C$ receives $\nu_C w - c_C$ while $D$ receives $\nu_D(1-w)-c_D$. If $D$ engages in military preparation but allows $C$ to acquire control of $x$, $C$ receives $\nu_C x$ while $D$ receives $\nu_D(1-x)-\kappa$. If $D$ engages in military preparation and does not allow $C$ to acquire $x$, then $C$ receives $\nu_C w_m - c_C$ and $D$ receives $\nu_D(1-w_m)-c_D-\kappa$.

Before discussing equilibrium behavior under the different assumptions about uncertainty, let us return to the example above. Suppose that $C$ sets $x = 0.2$ when $C$ observes military preparation and $x = 0.7$ otherwise. If $C$ is uncertain about $\nu_D$, knowing only that $\nu_D = 1$ with probability $q_\nu$ and $\nu_D = 2$ otherwise, and the cost of military preparation for war is 0.75, then it is possible that $D$ would engage in military preparations if and only if relatively resolved. If we stipulate that the less resolved type would concede to either demand, we see that he does not profit from mimicking the behavior of the more resolved type. If the less resolved type were to do so, he would receive $\underline{\nu}_D(1-0.2)-0.75$, or 0.05. If he instead foregoes military preparation, he receives $\underline{\nu}_D(1-0.7)$, or 0.3. But it is immediately obvious that the same cannot be said if the types share the same $\nu_D$. Put simply, the logic of costly signaling critically depends upon a type-dependent benefit of *appearing to be* a certain type. This necessarily applies when types differ with respect to the value they ascribe to the disputed good, but it cannot when they differ with respect to how satisfied they would be with an outcome that does not occur in equilibrium if costly signaling is successful.

Having described the model and the structure of each type of uncertainty, I now turn to a more detailed discussion of costly signaling.

## Costly Signaling

It is useful to first elaborate further on the traditional treatment of costly signaling. Slantchev (2011, 14) analyzes several variants of what he calls the Basic Crisis Game, some of which are analogous to the models analyzed in Fearon (1997).

In most of the models Slantchev considers, it is assumed that a crisis has already begun and the defender must decide between resistance and appeasement.[15] Should the defender resist the challenger's claim, the challenger must then decide whether to press her claim. If she does not, backing down instead, the defender retains full possession of the disputed good. If she does so, the defender must then decide whether to escalate, in which case the game ends in war, or back down, in which case the challenger acquires full control of the good. In the event of war, full control of the good goes to the victor while the loser surrenders their claim. In other words, the good in dispute is implicitly assumed to be indivisible.

Despite the fact that this model hardwires in one of the core rationalist explanations for war identified by Fearon (1995), war never occurs under complete information in the Basic Crisis Game because Slantchev (2011, 15) assumes that war is not only costly, but *so* costly that even the most resolved actors prefer not having the disputed good to fighting a war over it, all else equal.[16] Thus, either the challenger refuses to press her claim (when she knows the defender will escalate) or the defender appeases the challenger at the outset of the crisis. Equilibria involving a non-zero probability of war are only possible then under (two-sided) incomplete information, where the defender sometimes resists hoping that the challenger will back down only to discover that she is unwilling to do so. Accordingly, the occurrence of war in this model, like so many others since Fearon (1995), necessarily involves *ex post* regret—had the defender known from the outset that the challenger would press her claim, he would have preferred appeasement to resistance.

[15] However, in chapter 5, Slantchev extends the Military Threat Model (MTM) to allow the challenger an initial decision over whether to begin a crisis.

[16] However, the presence of audience costs ensures that states might prefer war to backing down once the crisis has reached a certain stage.

After discussing the Basic Crisis Game, Slantchev considers a series of extensions. Here, the mere availability of a policy instrument whose use can signal resolve typically ensures that the defender never threatens to use force unless he is in fact willing to do so.[17] Thus, if (and only if) the challenger observes the signal, she knows the defender is relatively resolved.

While the mere availability of costly signaling generally eliminates the possibility of bluffing in the models Slantchev considers, it does not eliminate the possibility of war. Even after the defender reveals that he is sufficiently resolved that he will escalate the crisis should the challenger press her claim, she sometimes does so in order to avoid the cost of backing down. In such cases, war involves *ex post* regret on the part of the defender, but no regret at all on the part of the challenger, who's only explicitly modeled decision is made in full awareness that a war whose only expected value is allowing her to avoid the cost of backing down after initiating a crisis will result. The challenger runs headlong into an outcome widely viewed as inefficient since Fearon (1995), and assumed by Slantchev (2011) to be so destructive that both sides expect to be made worse off than they would be if the good itself had never existed, simply because *the game form allows her no other option.*

This is less worrisome than the exclusive focus on uncertainty about resolve. The substantive conclusions that Slantchev emphasizes the most, such as the claim that military preparations can reduce the risk of war, or that more powerful nations may have to mobilize more heavily for their actions to signal resolve, do not depend upon whether the challenger is willing to press her claim despite knowing that war will result. But I stress the results under uncertainty about resolve presented here differ in some respects from those found in Slantchev (2011), and they do so because I allow for bargaining. As a result, once the challenger's uncertainty about the defender is removed, so too is the risk of war. Put differently, equilibria in which costly signaling occurs are necessarily peaceful. And while I do not wish to make too much of this difference, it is not a trivial one. (Slantchev 2011, 5) argues "The

[17]Bluffing may occur in equilibrium if the level of resolve for the most resolved defender is sufficiently low; if certain non-intuitive assumptions are made about the beliefs held by the challenger off the equilibrium path; if the defender cannot generate arbitrarily large audience costs; or if the instrument employed for costly signaling is issuing a threat that leaves something to chance. See Slantchev (2011, 31–46) for details.

likelihood of war depends on the extent to which one is prepared to use military threats to deter challenges to peace and compel concessions without fighting." However, *even* if we stipulated that uncertainty about resolve was the only important source of uncertainty, this argument would be suspect. If peace obtains regardless of whether the defender engages in military preparations, if the decision *not* to prepare for war can itself speak volumes and alleviate the information problem that might otherwise have caused war, as is indeed the case in an equilibrium I discuss below, then the extent to which one is prepared to use the military instrument has an important impact on the distributive character of agreements, but not on *whether* agreements are reached.

Nonetheless, there are many important similarities between my approach and that of Slantchev (2011). In both cases, the credible revelation of private information by the defender strictly harms less resolved types. For Slantchev, that is because separating equilibria require less resolved defenders to surrender full control of the good in dispute where they might have otherwise succeeded in persuading the challenger to back away from her claim. Here, separating equilibria force less resolved defenders to make larger concessions than they otherwise might have. Either way, less resolved defenders not only forego military preparation, but would prefer that the option not have been available in the first place. Moreover, in both cases, use of the military instrument not only reveals information about a pre-existing characteristic of the defender—the value he attaches to the disputed good—but also improves him to credibly threaten war under a wider range of conditions that would otherwise have been the case. For Slantchev, that means that more types of defender are willing to escalate at the final stage as the level of military preparation increases. Here, it means that fewer values of $x$ are acceptable to a relatively resolved $D$ who has prepared for war than a relatively resolved $D$ who has not prepared for war. In both cases, In short, while there is one important difference between our approaches—challengers never choose strategies that are sure to result in war here, as they do in Slantchev (2011)—there is no disagreement between us over the military instrument's effectiveness when it comes to signaling resolve.

Let us now turn to a more formal characterization of the results.

For the version of the model where $C$ is uncertain about the size of $\nu_D$, let $q'_{n,\nu}$ denote $C$'s updated belief that $\nu_D = \underline{\nu}_D$ after she observers $D$ choose not to engage in military preparations for war, and let $q'_{m,\nu}$ denote $C$'s updated belief that $\nu_D = \underline{\nu}_D$ after she observes military preparations.[18] Similarly, let $q'_{n,e}$ denote $C$'s updated belief that $e_D = \underline{e}_D$ if she does not see $D$ engage in military preparations and let $q'_{m,e}$ denote her updated belief that $e_D = \underline{e}_D$ if she does observe $D$ engage in military preparations.[19] Finally, for ease of exposition, let $u \in \{\nu, e\}$ index the source of $C$'s uncertainty.

In both cases, we are interested in the existence of perfect Bayesian equilibria in which $C$ sets $x = \overline{x}_{n,u}$ and holds the posterior belief $q'_{n,u} = 1$ if she does not observe $D$ engage in military preparation, and sets $x = \underline{x}_{m,u}$ and holds the posterior belief $q'_{m,u} = 0$ otherwise, while $D$ engages in military preparation if and only if he is the high type (i.e., if and only if $\nu_D = \overline{\nu}_D$ for the version where $C$ is uncertain about $\nu_D$ and if and only if $e_D = \overline{e}_D$ for the version where $C$ is uncertain about $e_D$).[20]

For ease of exposition, let such equilibria be called **Successful Signaling Equilibria**. This brings us to our first result.

**Proposition 1.** *When the challenger is uncertain about the defender's resolve, there exists a Successful Signaling Equilibrium.*

**Corollary 1.** *When the challenger is uncertain about the defender's martial effectiveness, no Successful Signaling Equilibrium exists to the model with military preparation.*

Proposition 1 tells us that the military instrument facilitates costly signaling when $C$ is uninformed about $\nu_D$. Corollary 1 tells us that the same is not true when $C$'s uncertainty pertains to $e_D$. The intuition behind this difference, again, is that there must be disincentive for mimicking the behavior of the higher type. Such a disincentive requires that equilibrium

[18] Thus, $C$ believes $\nu_D = \overline{\nu}_D$ with probability $1 - q'_{n,\nu}$ in the former case and $1 - q'_{m,\nu}$ in the latter.

[19] And thus $C$ believes $e_D = \overline{e}_D$ with probability $1 - q'_{n,e}$ in the former case and $1 - q'_{m,e}$ in the latter.

[20] See the appendix for derivations of $\underline{x}_{n,\nu}$, $\underline{x}_{m,\nu}$, $\overline{x}_{n,\nu}$, $\overline{x}_{m,\nu}$, $\underline{x}_{n,e}$, $\underline{x}_{m,e}$, $\overline{x}_{n,e}$, $\overline{x}_{m,e}$, and all other critical values as well as proofs of the propositions.

payoffs depend upon $D$'s type, as discussed above. When the quality that $D$ wishes to signal to $C$ is that he attaches a relatively high value to the issue in dispute, the benefit of succeeding in convincing $C$ of this is by its very nature greater if he in fact possesses this quality.[21] But the benefit of persuading $C$ that $D$ is good at the conduct of war is, within a Successful Signaling Equilibrium, independent of that quality, because the only payoffs affected by differences in martial effectiveness are those pertaining to outcomes that do not occur in equilibrium if $C$'s uncertainty about $D$'s type is eliminated. Thus, there can be no such equilibrium when $C$ is uncertain about $D$'s martial effectiveness.

This is not to say that it is impossible for those whose militaries are exceptionally well-trained to move the priors of potential challengers. As (Slantchev 2011, 78–80) argues, certain feats might by their very nature reveal martial effectiveness, in the sense that a less martially effective fighting force would be *unable* to mimic them. For example, the air shows once performed by the Blue Angels, an elite squadron of US fighter pilots, feature maneuvers that would surely end in disaster if the pilots were not exceptionally talented.[22] But such displays offer noisy signals at best. Both Slantchev (2003) and Powell (2004) note that battlefield outcomes serve as noisy signals of a states relative ability to win battles, as there is surely no better indicator of the ability to win battles than winning battles,, yet it can still take a while for belief convergence to occur in equilibrium. Powell even argues that uncertainty about resolve can be reduced more quickly than uncertainty about the ability to win battles. Thus, while I acknowledge that Corollary 1 does not rule out the possibility of reducing uncertainty about martial effectiveness, it is nonetheless an important result. Together with Proposition 1, it suggests that the mere *availability* of the military instrument is often sufficient to prevent wars due to miscalculation about resolve, but the risk of wars due to miscalculation about martial effectiveness is not so trivial.

Let us now consider how military preparation for war affects this risk.

[21]More formally, $\overline{\nu}_D(1-x) > \underline{\nu}_D(1-x) \; \forall \; x$.

[22]The author, whose grandfather served as a pilot in the Navy, has attended several air shows that were not open to the general public and can attest to the impression the Blue Angels make even while they are still in training.

## War and Uncertainty Over Martial Effectiveness

Generally speaking, the challenger's willingness to risk war when uncertain about what terms the defender will accept depends upon three factors: the likelihood that gambling would pay off; the relative upside to gambling; and the relative downside to gambling. The first is captured by $q'_{\cdot,u}$. The second refers to the relative difference between $C$'s value for having the defender concede to a relatively large demand, which is $\nu_C\overline{x}_{\cdot,u}$, versus her value for having him concede to a smaller one, $\nu_C\underline{x}_{\cdot,u}$. The third refers to the relative difference between the challenger's value for having the defender concede to a relatively small demand, which again is $\nu_C\underline{x}_{\cdot,u}$, and her value for fighting a war, or $\nu_C w - c_C$. All else equal, as the upside to gambling ($\nu_C\overline{x}_{\cdot,u} - \nu_C\underline{x}_{\cdot,u}$) decreases or the downside to gambling ($\nu_C\underline{x}_{\cdot,u} - \nu_C w - c_C$) increases, $C$ becomes more likely to play it safe by setting $x = \underline{x}_{\cdot,u}$. As the upside to gambling increases or the downside decreases, $C$ becomes more likely to instead set $x = \overline{x}_{\cdot,u}$.

Having established that the willingness to use military preparations cannot reveal information about martial effectiveness—i.e., cannot affect $q'_{\cdot,e}$—we now ask how they influence the relative upside and downside to gambling.

This leads us to our next result.

**Proposition 2.** *When the challenger is uncertain about the defender's martial effectiveness, there exists a perfect Bayesian equilibrium (PBE) to the model with military preparation in which military preparations prevent war without revealing information.*

More formally, Proposition 2 refers to a PBE in which $C$ sets $x = \overline{x}_{n,e}$ if $D$ does not engage in military preparations and sets $x = \underline{x}_{m,e}$ if $D$ does, indicating that $C$ would risk war if $D$ chose not to engage in military preparations, but since both types will do so in equilibrium, $C$ will play it safe and war will be averted.

The intuition here is that if either the relative upside or downside to gambling changes sufficiently, then $C$'s willingness to gamble will change, even if her estimate of the likelihood that her gamble will pay off does not.

To extend the metaphor, suppose one was offered a choice between \$4.50 for sure and an opportunity to win \$10 by successfully predicting the outcome of a coin flip. Unless one was relatively risk-averse, one would likely find the coin flip more attractive. But if the \$4.50 dropped to \$4 and the potential winnings from the coin flip dropped from \$10 to \$7, one would likely start to find the sure thing more attractive, at least provided one was not particulary risk-acceptant. Yet no new information has been received about how likely one is to win the coin flip. All that has changed is the relative upside and downside to gambling.

Something similar can happen when both types of $D$ prepare for war. This reduces the largest demands each type of $D$ would be willing to accept (generically denoted $\overline{x}_{\cdot,u}$ for the type with $e_D = \underline{e}_D$ and $\underline{x}_{\cdot,u}$ for the type with $e_D = \overline{e}_D$), which is equivalent to reducing the potential winnings from gambling while also reducing the amount that's available for sure as an alternative to gambling.[23] With all three available outcomes growing less attractive, $C$ is clearly worse off when both types of $D$ prepare for war. But that's only to be expected. The less obvious, but no less important, point is that $C$'s willingness to gamble might change, depending on *how much* each payoff decreases relative to the others. Moving back towards the language of the model, if the difference between $\overline{x}_{n,e}$ and $\underline{x}_{n,e}$ is greater than the difference between $\overline{x}_{n,e}$ and $\underline{x}_{n,e}$, then $C$ has less incentive to risk war if both types prepare for war than if neither does because there is less to be gained from gambling.

Where Corrolary 1 establishes that eliminating uncertainty is often less feasible than we realize, Proposition 2 argues that it is also less necessary to do so; that even if the primary cause of war is uncertainty, revealing information need not play any role in its prevention, contra Kydd and others. Manipulating material incentives can be every bit as effective, and may often be more feasible.[24]

[23]It also reduces $C$'s expected payoff from having to fight a war against the more martially effective type in the event that her gamble does not payoff. In the context of the coin flip example, this would be equivalent to introducing the possibility of losing money from coin flip, rather than simply failing to win any.

[24]Note that Fey and Ramsay (2010) and Arena and Pechenkina (N.d.) make a similar point in the context of conflict management, arguing that mediation as information revelation rarely succeeds while mediation as manipulation of material incentives is viable under a wide range of circumstances. Moreover, Arena and Wolford (2012) demonstrate that reducing uncertainty can make war more likely, further casting doubt on the notion that conflicts caused by information problems are best resolved by providing more information.

However, Proposition 2 describes but one possibility.

**Proposition 3.** *When the challenger is uncertain about the defender's martial effectiveness, there exists a PBE to the model with military preparation in which military preparations are destabilizing yet both types of defender engage in military preparations.*

More formally, Proposition 3 refers to a PBE in which $C$ sets $x = \underline{x}_{n,e}$ if $D$ does not engage in military preparations and sets $x = \overline{x}_{m,e}$ if $D$ does, and thus war is possible if and only if $D$ engages in military preparations, and yet both types of $D$ do so in equilibrium.

This may seem surprising. Why would the defender pursue a strategy he knows to be destabilizing? The key to understanding Proposition 3 is to recognize that while no state strictly prefers to see a crisis escalate to war, states may be willing to accept the possibility of war if doing so is necessary to achieve a better distributive outcome.

Consider the following hypothetical scenario. Suppose that the challenger presently enjoys an advantage in terms of military capabilities, with $m_C = 5$ and $m_D = 1$. Suppose further that $C$'s forces are quite good at the conduct of war, with $e_C = 2$, though she believes it possible that $D$'s are as well, with $\overline{e}_D = 2$. On the other hand, she also believes it possible that $D$'s forces are substantially less effective, with $\underline{e}_D = 1$. For the sake of simplicity, assume $C$ believes these two scenarios equally likely (i.e., $q = 0.5$). In this case, should war occur without $D$ first engaging in military preparations, the outcome would be expected to favor the challenger. It is unlikely to come to that, however. The difference between $\overline{x}_{n,e}$ and $\underline{x}_{n,e}$) would be relatively trivial, with the former being roughly equal to 0.96 and the latter 0.88. With such a small upside to gambling, if neither type of $D$ prepared for war, $C$ would likely play it safe and set $x = \underline{x}_{n,e}$, which $D$ would accept regardless of type.[25]

Now suppose that both types of $D$ engage in military preparations and that the benefit of doing so is fairly substantial, with $\beta = 3$. The challenger's uncertainty over the defender's martial effectiveness would now make quite a bit of difference, as $\overline{x}_{m,e}$ would be 0.82 and $\underline{x}_{m,e}$

[25] As discussed in the appendix, $C$ sets $x = \overline{x}_{n,e}$ here iff $q'_{n,e} > \hat{q}_{n,e}$, setting $x = \underline{x}_{n,e}$ otherwise. Let $c_C = c_D = 0.05$ and $\nu_C = \nu_D = 1$. Then $\hat{q}_{n,e}$ would be approximately 0.57. This being greater than $q'_{n,e}$, which would simply equal $q$, or 0.5, if both types chose not to prepare for war, $C$ would set $x = \underline{x}_{n,e}$.

would be approximately 0.68. With the upside to gambling now a bit larger, the challenger would choose to risk war setting $x = \overline{x}_{m,e}$.[26] Yet, if $\kappa$ is sufficiently small, both types of $D$ will engage in military preparations. For the less martially effective type, doing so allows him to retain an additional 6% of the disputed good. For the more martially effective type, preparing for war means fighting a war that will leave him feeling as though he's retained an additional 26% of the disputed good, even after factoring in the costs of fighting a war that would not have occurred if he'd foregone military preparations.

What distinguishes between situations where military preparations promote war versus those where they prevent it? As the discussion above suggests, the answer lies in whether the difference between the maximum demands acceptable to each type increases or decreases as a result of military preparation for war. This is itself primarily a function of the initial distribution of military capabilities.

**Proposition 4.** *Military preparations for war lead the challenger to gamble under a wider range of conditions if the defender's initial military capabilities are sufficiently small, otherwise leading her to gamble under a narrow range of conditions.*

Proposition 4 tells us that military preparations encourage $C$ to risk war when $D$ is relatively weak initially, but discourage $C$ from doing so when $D$ begins from a position of relative strength. The intuition here is that military preparations move the two sides towards parity when $D$ is initially weak, and shifts towards parity increase the likelihood that $D$'s martial effectiveness will be the determining factor of any military contest, acting as a tie-breaker. Thus, provided the defender is relatively weak and his martial effectiveness is private information, military preparations will not only fail to eliminate $C$'s information problem, but will exacerbate it. The defender may still find them worthwhile, but we should understand that the consequences thereof may differ from what Slantchev (2011) suggests.

[26] As discussed in the appendix, $C$ sets $x = \overline{x}_{m,e}$ here iff $q'_{m,e} > \hat{q}_{m,e}$, setting $x = \underline{x}_{m,e}$ otherwise. Again letting $c_C = c_D = 0.05$ and $\nu_C = \nu_D = 1$, $\hat{q}_{m,e}$ would be approximately 0.41. This being less than $q'_{m,e}$, which as before would simply equal 0.5, if both types prepared for war, $C$ would set $x = \overline{x}_{m,e}$.

## Conclusion

To some extent, the results of this analysis reaffirm extant claims about costly signaling. Specifically, I find that the relatively resolved defenders can and often will signal their resolve through costly military preparations. However, other results challenge or at least refine our understanding of costly signaling and the policy instrument most associated therewith. While useful for signaling resolve, military preparations cannot be used to signal superior martial effectiveness. This is particularly concerning because there is little reason to believe that *any* policy instrument might facilitate costly signaling about martial effectiveness.

Moreover, if the challenger is uncertain about the defender's martial effectiveness—as I have argued challengers must always be, at least to some extent—then the very policy instrument that best facilitates costly signaling of resolve might nonetheless prove destabilizing, provided the defender entered the crisis in a position of weakness. To be sure, it can also discourage risk-taking on behalf of the challenger. Ultimately, whether preparations for war prevent or promote war may depend on the initial distribution of capabilities.

That the mere *availability* of military preparations is often sufficient to eliminate uncertainty about resolve but not about martial effectiveness, and that wars fought due to uncertainty about martial effectiveness are most likely to occur between states of roughly equal military capabilities, is consistent with evidence that parity is strongly associated with war onset.[27] It is unclear, however, why such a pattern should emerge if costly signaling worked as well, and as unconditionally, as many believe it does. There might reasons why states near parity would be more reluctant to engage in costly signaling, but this analysis suggests a simpler explanation—some forms of uncertainty cannot be eliminated through costly signaling, and they pose a greater obstacle to efficient bargaining when states possess roughly equal military capabilities. It might behoove us to assume that, in equilibrium, uncertainty about resolve is rarely the primary obstacle to peace.

[27]See, inter alia, Organski and Kugler (1980), Lemke and Werner (1996), Lemke (2002), Reed (2003), and Bennett and Stam (2004).

Variation in the incidence of war may thus have little to do with variation in the number of policy instruments through which costly signals of resolve can ostensibly be sent. Though some attribute the peace between democracies to their greater ability to generate audience costs,[28] and others attribute the correlation between economic interdependence and peace to a greater ability of interdependent states to signal resolve via threats to sever economic ties,[29] the results here suggest that such interpretations are problematic.[30]

Finally, I close by observing that while preparing for war may at times encourage its occurrence, this does not by any means imply that it is unwise for defenders to prepare for war. Those of us who study matters of war and peace for a living often assume that the primary goal of statecraft is to avoid war. Yet we have good reason to believe that states care about who gets what as much as they do the means by which any given allocation is determined. Put differently, if preparing for war ensures its onset, but also ensures the defender a significantly larger share of the disputed good, we ought not be surprised if some states do so. Nonetheless, it might not be wise to argue that those who seek to prevent war are always and everywhere best served by preparing for it.

[28]See especially Fearon (1994).

[29]See especially Gartzke, Li, and Boehmer (2001) and Gartzke (2007). However, see also Polachek and Xiang (2010) who argue that economic interdependence promotes peace by altering the material incentives states face, not their information environment, consistent with the argument developed here.

[30]Previous drafts of this paper analyzed models in which $D$ had the option of generating audience costs or threatening to sever economic ties. The results were not encouraging for proponents of costly signaling. However, the paper was overlong and difficult to follow with these additional models, so for the sake of clarity and brevity, I have omitted them.

# Appendix

Before turning to the proofs of the propositions, it is useful to establish a few preliminaries.

Generically speaking, $D$ accepts if and only if (iff) $u_D(\text{neg}) \geq u_D(\text{war})$, or iff

$$\nu_D(1-x) \geq \nu_D(1-w) - c_D. \tag{1}$$

This can be rewritten as

$$x \leq w + \frac{c_D}{\nu_D}. \tag{2}$$

Suppose $C$ is uncertain about $D$'s resolve. For the less resolved type, with $\nu_D = \underline{\nu}_D$, $u_D(\text{neg}) \geq u_D(\text{war})$ is generically equivalent to

$$x \leq w + \frac{c_D}{\underline{\nu}_D} \equiv \overline{x}_{\cdot,\nu}. \tag{3}$$

The more resolved type can similarly be shown to accept iff $x \leq \underline{x}_{\cdot,\nu}$, where $\underline{x}_{\cdot,\nu} \equiv w + \frac{c_D}{\overline{\nu}_D}$.

That is, when $D$ did not engage in military preparations and is relatively low in resolve, he accepts iff $x \leq \overline{x}_{n,\nu}$, where $\overline{x}_{n,\nu} \equiv w_n + \frac{c_D}{\underline{\nu}_D}$, and if he is relatively high in resolve, he accepts iff $x \leq \underline{x}_{n,\nu}$, where $\underline{x}_{n,\nu} \equiv w_n + \frac{c_D}{\overline{\nu}_D}$. When $D$ engages in military preparations, he accepts iff $x \leq \overline{x}_{m,\nu}$, where $\overline{x}_{m,\nu} \equiv w_m + \frac{c_D}{\underline{\nu}_D}$, when relatively low in resolve, and accepts iff $x \leq \underline{x}_{m,\nu}$, where $\underline{x}_{m,\nu} \equiv w_m + \frac{c_D}{\overline{\nu}_D}$, if relatively high in resolve.

Now suppose that $C$ is uncertain about $D$'s martial effectiveness. For the less martially effective $D$, with $e_D = \underline{e}_D$, $u_D(\text{neg}) \geq u_D(\text{war})$ is generically equivalent to

$$x \leq \overline{w} + \frac{c_D}{\nu_D} \equiv \overline{x}_{\cdot,e}. \tag{4}$$

Applying similar reasoning, we can readily establish that the more martially effective type accepts iff $x \leq \underline{x}_{\cdot,e}$, where $\underline{x}_{\cdot,e} \equiv \underline{w} + \frac{c_D}{\nu_D}$.

That is, without military preparations $D$ accepts iff $x \leq \overline{x}_{n,e}$, where $\overline{x}_{n,e} \equiv \underline{w}_n + \dfrac{c_D}{\nu_D}$, if relatively low in martial effectiveness, and iff $x \leq \underline{x}_{n,e}$, where $\underline{x}_{n,ee} \equiv \overline{w}_n + \dfrac{c_D}{\nu_D}$, if relatively high in martial effectiveness. When $D$ does engage in military preparations, on the other hand, he accepts iff $x \leq \overline{x}_{m,e}$, where $\overline{x}_{m,e} \equiv \underline{w}_m + \dfrac{c_D}{\nu_D}$, when relatively low in martial effectiveness, and iff $x \leq \underline{x}_{m,e}$, where $\underline{x}_{m,e} \equiv \overline{w}_m + \dfrac{c_D}{\nu_D}$, if relatively high in martial effectiveness.

$C$ can thus readily infer the following

$$pr(\text{war}) = \begin{cases} 0 & \text{if } x \leq \underline{x}_{\cdot,u} \\ 1-q & \text{if } \underline{x}_{\cdot,u} < x \leq \overline{x}_{\cdot,u} \\ 1 & \text{if } x > \overline{x}_{\cdot,u}, \end{cases}$$

and

$$E(u_C(x)) = \begin{cases} \nu_C x & \text{if } x \leq \underline{x}_{\cdot,u} \\ q(\nu_C x) + (1-q)(\nu_C w - c_C) & \text{if } \underline{x}_{\cdot,u} < x \leq \overline{x}_{\cdot,u} \\ \nu_C w - c_C & \text{if } x > \overline{x}_{\cdot,u}. \end{cases}$$

We can immediately establish that $C$ never sets $x < \underline{x}_{\cdot,u}$, $x > \overline{x}_{\cdot,u}$ or $x = x_1$ where $x_1 \in (\underline{x}_{\cdot,u}, \overline{x}_{\cdot,u})$. When $C$ sets $x \leq \underline{x}_{\cdot,u}$, $D$ is certain to accept regardless of type, and so $u_C(x \leq \underline{x}_{\cdot,u}) = \nu_C x$. Thus, it follows that $u_C(x < \underline{x}_{\cdot,u})$ is strictly dominated by $u_C(x = \underline{x}_{\cdot,u})$.

Since $E(u_C(x = x_1)) \geq E(u_C(x = \overline{x}_{\cdot,u}))$ is equivalent to

$$q(\nu_C x_1) + (1-q)(\nu_C w - c_C) \geq q(\nu_C \overline{x}_{\cdot,u}) + (1-q)(\nu_C w - c_C), \tag{5}$$

or $x_1 \geq \overline{x}_{\cdot,u}$, which cannot be true, setting $x = x_1$ is strictly dominated by $x = \overline{x}_{\cdot,u}$.

Finally, because $E(u_C(x > \overline{x}_{\cdot,u})) \geq E(u_C(x = \overline{x}_{\cdot,u}))$ is equivalent to

$$q(\nu_C w - c_C) + (1-q)(\nu_C w - c_C) \geq q(\nu_C \overline{x}_{\cdot,u}) + (1-q)(\nu_C w - c_C), \tag{6}$$

which cannot be true due to the inherent inefficiency of war, setting $x > \overline{x}_{\cdot,u}$ is strictly dominated by setting $x = \overline{x}_{\cdot,u}$.

Thus the only values of $x$ that $C$ selects in equilibrium are $x = \underline{x}_{\cdot,u}$, which $D$ accepts regardless of type, and $x = \overline{x}_{\cdot,u}$, which $D$ accepts with probability $q$.

We now turn to evaluating $u_C(x = \underline{x}_{\cdot,\nu}) \geq EU_C(x = \overline{x}_{\cdot,\nu})$ and $u_C(x = \underline{x}_{\cdot,e}) \geq EU_C(x = \overline{x}_{\cdot,e})$. Starting again with the variant of the model where $C$ uncertain about $D$'s resolve, when $D$ does not prepare for war, $u_C(x = \underline{x}_{n,\nu}) \geq EU_C(x = \overline{x}_{n,\nu})$ is equivalent to

$$\nu_C \underline{x}_{n,\nu} \geq q'_{n,\nu}(\nu_C \overline{x}_{n,\nu}) + (1 - q'_{n,\nu})(\nu_C w_n - c_C), \tag{7}$$

or

$$q'_{n,\nu} \leq \frac{c_C + c_D(\frac{\nu_C}{\overline{\nu}_D})}{c_C + c_D(\frac{\nu_C}{\underline{\nu}_D})}. \tag{8}$$

When $D$ prepares for war, $u_C(x = \underline{x}_{m,\nu}) \geq EU_C(x = \overline{x}_{m,\nu})$ is equivalent to

$$\nu_C \underline{x}_{m,\nu} \geq q'_{m,\nu}(\nu_C \overline{x}_{m,\nu}) + (1 - q'_{m,\nu})(\nu_C w_m - c_C), \tag{9}$$

or

$$q'_{m,\nu} \leq \frac{c_C + c_D(\frac{\nu_C}{\overline{\nu}_D})}{c_C + c_D(\frac{\nu_C}{\underline{\nu}_D})}. \tag{10}$$

That is, when $C$ is uncertain about $D$'s resolve, whether $D$ prepares for war influences the posterior belief relevant to $C$'s decision, but not the threshold against which that belief is compared. In other words, military preparations have no effect on the minimum level of $q'_{\cdot,\nu}$ for which $C$ finds risking war worthwhile. We can therefore ignore $D$'s initial decision and say that $C$ sets $x = \overline{x}_{\cdot,\nu}$ iff $q'_{\cdot,\nu} \geq \hat{q}_\nu$, where $\hat{q}_\nu \equiv \dfrac{c_C + c_D(\dfrac{\nu_C}{\overline{\nu}_D})}{c_C + c_D(\dfrac{\nu_C}{\underline{\nu}_D})}$.

Note that since $c_C + c_D(\dfrac{\nu_C}{\overline{\nu}_D}) < c_C + (c_D\dfrac{\nu_C}{\underline{\nu}_D}) \Leftrightarrow \underline{\nu}_D < \overline{\nu}_D$, it must be true that $\hat{q}_\nu \in (0, 1)$.

However, $D$'s initial choice is more consequential when $C$ is uncertain about $D$'s martial effectiveness. In this case, when $D$ does not prepare for war, the relevant comparison is $u_C(x = \underline{x}_{n,e}) \geq EU_C(x = \overline{x}_{n,e})$, which is equivalent to

$$\nu_C\underline{x}_{n,e} \geq q'_{n,e}(\nu_C\overline{x}_{n,e}) + (1 - q'_{n,e})(\nu_C\underline{w}_n - c_C), \tag{11}$$

or

$$q'_{n,e} \leq \frac{c_C + c_D(\dfrac{\nu_C}{\nu_D})}{\nu_C(\overline{w}_n - \underline{w}_n) + c_C + c_D(\dfrac{\nu_C}{\nu_D})} \equiv \hat{q}_{n,e}. \tag{12}$$

And when $D$ prepares for war, $u_C(x = \underline{x}_{m,e}) \geq EU_C(x = \overline{x}_{m,e})$ is equivalent to

$$\nu_C\underline{x}_{m,e} \geq q'_{m,e}(\nu_C\overline{x}_{m,e}) + (1 - q'_{m,e})(\nu_C\underline{w}_m - c_C), \tag{13}$$

or

$$q'_{m,e} \leq \frac{c_C + c_D(\dfrac{\nu_C}{\nu_D})}{\nu_C(\overline{w}_m - \underline{w}_m) + c_C + c_D(\dfrac{\nu_C}{\nu_D})} \equiv \hat{q}_{m,e}. \tag{14}$$

Having identified $D$'s acceptance rules, which will not vary across the equilibria, and characterized $C$'s choice of $x$ for any given belief about $\nu_D$ or $e_D$ (that is, for any given value of $q'_{\cdot,\nu}$ and $q'_{\cdot,e}$, as appropriate), we are ready to evaluate the propositions.

## Proofs of the Propositions

*Proposition 1.* The following beliefs and strategies comprise a PBE: $C$ sets $x = \overline{x}_{n,\nu}$ and believes $q'_{n,\nu} = 1$ if $D$ does not prepare for war and sets $x = \underline{x}_{m,\nu}$ and believes $q'_{m,\nu} = 0$ if $D$ does so; the less resolved type of $D$ accepts iff $x \leq \overline{x}_{n,\nu}$ when he does not employ the military instrument, accepts iff $x \leq \overline{x}_{m,\nu}$ if he does, but does not engage in military preparations; and the more resolved type accepts iff $x \leq \underline{x}_{n,\nu}$ if he does not employ the military instrument, accepts iff $x \leq \underline{x}_{m,\nu}$ if he does, and does engage in military preparations.

Note that $pr(\nu_D = \underline{\nu}_D|m) = \dfrac{pr(m|\nu_D = \underline{\nu}_D) \cdot pr(\nu_D = \underline{\nu}_D)}{pr(m|\nu_D = \underline{\nu}_D) \cdot pr(\nu_D = \underline{\nu}_D) + pr(m|\nu_D = \overline{\nu}_D) \cdot pr(\nu_D = \overline{\nu}_D)}$ and $pr(\nu_D = \underline{\nu}_D|n) = \dfrac{pr(n|\nu_D = \underline{\nu}_D) \cdot pr(\nu_D = \underline{\nu}_D)}{pr(n|\nu_D = \underline{\nu}_D) \cdot pr(\nu_D = \underline{\nu}_D) + pr(n|\nu_D = \overline{\nu}_D) \cdot pr(\nu_D = \overline{\nu}_D)}$ by Bayes' Theorem, where $m$ indicates that $D$ engaged in military preparations and $n$ that $D$ did not. The updated beliefs stipulated above thus follow readily, since $pr(m|\nu_D = \underline{\nu}_D) = 0$, $pr(m|\nu_D = \overline{\nu}_D) = 1$, $pr(n|\nu_D = \underline{\nu}_D) = 1$ and $pr(n|\nu_D = \overline{\nu}_D) = 0$.

Given these posterior beliefs, the optimality of $C$'s demands follows readily, since $C$ sets $x = \underline{x}_{\cdot,\nu}$ iff $q'_{\cdot,\nu} \leq \hat{q}_\nu$ and $0 \leq \hat{q}_n u$ and $1 > \hat{q}_\nu$ trivially hold.

Thus, $C$'s beliefs and strategies are sequentially rational and consistent with Bayes' Theorem. All that remains is to consider the incentive compatibility conditions for $D$.

Holding constant $C$'s beliefs and strategies, the less resolved type receives $\underline{\nu}_D(1 - \overline{x}_{n,\nu})$ if he abides by the equilibrium and $\underline{\nu}_D(1 - \underline{x}_{m,\nu}) - \kappa$ if he employs the military instrument.

Thus incentive compatibility requires $\kappa \geq \underline{\kappa}_\nu$, where $\underline{\kappa}_\nu \equiv \underline{\nu}_D(w_n - w_m + \dfrac{c_D}{\underline{\nu}_D} - \dfrac{c_D}{\overline{\nu}_D})$.

If the relatively resolved type complies with the equilibrium strategy, he receives $\overline{\nu}_D(1 - \underline{x}_{m,\nu}) - \kappa$. If he deviates, he will reject $\overline{x}_{n,\nu}$ and receive $\overline{\nu}_D(1 - w_n) - c_D$. Thus, incentive compatibility for this type requires $\kappa \leq \overline{\kappa}_\nu$, where $\overline{\kappa}_\nu \equiv \overline{\nu}_D(w_n - w_m)$.

So long as $\underline{\kappa}_\nu < \overline{\kappa}_\nu$, there are certain to be values of $\kappa$ that satisfy both incentive compatibility constraints, and thus establish the equilibrium. Inspecting the two terms, it is readily apparent that this may indeed be the case, provided $c_D$ is sufficiently small and the difference between $\underline{\nu}_D$ and $\overline{\nu}_D$ is sufficiently large. □

*Corollary 1.* It is useful to recall that

$$w = \begin{cases} \underline{w} \equiv \dfrac{e_C m_C}{e_C m_C + \overline{e}_D m_D} & \text{if } e_D = \overline{e}_D \text{ and no military preparations} \\ \overline{w} \equiv \dfrac{e_C m_C}{e_C m_C + \underline{e}_D m_D} & \text{if } e_D = \underline{e}_D \text{ and no military preparations} \\ \underline{w}_m \equiv \dfrac{e_C m_C}{e_C m_C + \overline{e}_D \beta m_D} & \text{if } e_D = \overline{e}_D \text{ and military preparations} \\ \overline{w}_m \equiv \dfrac{e_C m_C}{e_C m_C + \underline{e}_D \beta m_D} & \text{if } e_D = \underline{e}_D \text{ and military preparations.} \end{cases}$$

The following beliefs and strategies comprise the candidate PBE of interest: $C$ sets $x = \underline{x}_{m,e}$ and believes $q'_{m,e} = 0$ if $D$ engages in military preparations and sets $x = \overline{x}_{n,e}$ and believes $q'_{n,e} = 1$ if $D$ does not; the less martially effective type $D$ accepts iff $x \leq \overline{x}_{n,e}$ when he does not engage in military preparations, accepts iff $x \leq \overline{x}_{m,e}$ if he does, but does not prepare for war; and the more martially effective type accepts iff $x \leq \underline{x}_{n,e}$ if he does not engage in military preparations, accepts iff $x \leq \underline{x}_{m,e}$ if he does, and does prepare for war.

By the same logic as above, $C$'s strategies and beliefs are sequentially rational and consistent with Bayes' Theorem. So we turn to the incentive compatibility constraints for $D$.

Holding constant $C$'s beliefs and strategies, the less martially effective type receives $\nu_D(1 - \overline{x}_{n,e})$ if he abides by the equilibrium and $\nu_D(1 - \underline{x}_{m,e}) - \kappa$ if he does not.

Thus incentive compatibility requires $\kappa \geq \underline{\kappa}_e$, where $\underline{\kappa}_e \equiv \nu_D(\overline{w}_n - \underline{w}_m)$.

If the relatively martially effective type complies with the equilibrium strategy, he receives $\nu_D(1-\underline{x}_{m,e})-\kappa$. If he deviates, he will reject $\overline{x}_{n,e}$ and receive $\nu_D(1-\underline{w}_n)-c_D$. Thus, incentive compatibility for this type requires $\kappa \leq \overline{\kappa}_e$, where $\overline{\kappa}_e \equiv \nu_D(\underline{w}_n - \underline{w}_m)$.

So long as $\underline{\kappa}_e < \overline{\kappa}_e$, there are certain to be values of $\kappa$ that satisfy both incentive compatibility constraints, and thus establish the equilibrium.

We must therefore evaluate $\underline{\kappa}_e < \overline{\kappa}_e$, which is equivalent to

$$\nu_D(\overline{w}_n - \underline{w}_m) < \nu_D(\underline{w}_n - \underline{w}_m), \tag{15}$$

which simplifies to $\overline{w}_n < \underline{w}_n$, and clearly cannot be true. This establishes the result. □

*Proposition 2.* The following beliefs and strategies comprise a PBE: $C$ sets $x = \underline{x}_{m,e}$ and believes $q'_{m,e} \leq \hat{q}_{m,e}$ if $D$ engages in military preparations and sets $x = \overline{x}_{n,e}$ and believes $q'_{n,e} > \hat{q}_{n,e}$ if $D$ does not; the less martially effective type of $D$ accepts iff $x \leq \overline{x}_{n,e}$ when he does not engage in military preparations, accepts iff $x \leq \overline{x}_{m,e}$ if he does, and prepares for war; and the more martially effective type accepts iff $x \leq \underline{x}_{n,e}$ if he does not engage in military preparations, accepts iff $x \leq \underline{x}_{m,e}$ if he does, and prepares for war.

By Bayes' Theorem, $q'_{m,e} = q_e$, since $pr(m|e_D = \underline{e}_D) = pr(m|e_D = \overline{e}_D) = 1$. Since $pr(n|e_D = \underline{e}_D) = pr(n|e_D = \overline{e}_D) = 0$, Bayes' Theorem cannot be used to define $q'_{n,e}$. In contrast to the results for Successful Signal Equilibria, we cannot assert that $C$'s beliefs must take on values that will sustain the equilibrium. However, we can stipulate that $C$'s beliefs sometimes will take on such values without violating weak consistency with Bayes' Theorem. When they do, the strategies outlined above for $C$ will be sequentially rational.

That leaves only the question of incentive compatibility for $D$.

Holding constant $C$'s beliefs and strategies, the less martially effective type receives $\nu_D(1 - \underline{x}_{m,e}) - \kappa$ if he engages in military preparations per the equilibrium and $\nu_D(1 - \overline{x}_{n,e})$ if he deviates from the equilibrium strategies and does not prepare for war.

Thus incentive compatibility requires $\kappa \leq \underline{\kappa}_e$, as defined in the proof of Corollary 1.

Similarly, incentive compatibility for the more martially effective type of $D$ requires $\kappa \leq \overline{\kappa}_e$, where $\overline{\kappa}_e$ was also defined in the previous proof.

We have already established that $\underline{\kappa}_e$ must be greater than $\overline{\kappa}_e$. However, since this equilibrium requires that $\kappa$ be relatively low for both types, the problem we ran into above does not apply here. Provided $\kappa < \overline{\kappa}_e$, both types will be willing to engage in military preparations, as per the equilibrium. Since $\overline{\kappa}_e$ is strictly positive, there must be values of $\kappa$ that are sufficiently small to satisfy the incentive compatibility requirements for both types, and the equilibrium must therefore hold for at least some values of the parameters. Since Proposition 2 merely stipulates the existence of a perfect Bayesian equilibrium exhibiting certain qualities, this is sufficient to establish the result. □

*Proposition 3.* The following beliefs and strategies comprise a PBE: $C$ sets $x = \overline{x}_{m,e}$ and believes $q'_{m,e} > \hat{q}_{m,e}$ if $D$ engages in military preparations and sets $x = \underline{x}_{n,e}$ and believes $q'_{n,e} \leq \hat{q}_{n,e}$ if $D$ does not; the less martially effective type of $D$ accepts iff $x \leq \overline{x}_{n,e}$ when he does not engage in military preparations, accepts iff $x \leq \overline{x}_{m,e}$ if he does, and prepares for war; and the more martially effective type accepts iff $x \leq \underline{x}_{n,e}$ if he does not engage in military preparations, accepts iff $x \leq \underline{x}_{m,e}$ if he does, and prepares for war.

Again, Bayes' Theorem can only tell us that $q'_{m,e} = q_e$; it offers no guidance as to the value of $q'_{n,e}$. However, we can again stipulate that $C$'s beliefs sometimes will take on such values without violating weak consistency with Bayes' Theorem. When they do, the strategies outlined above for $C$ will be sequentially rational.

It is worth noting that even if $C$'s off-the-equilibrium-path belief matched her prior belief, the equilibrium might hold. This requires $\hat{q}_{m,e} < \hat{q}_{n,e}$, which is equivalent to

$$\frac{c_C + c_D(\frac{\nu_C}{\nu_D})}{\nu_C(\overline{w}_m - \underline{w}_m) + c_C + c_D(\frac{\nu_C}{\nu_D})} < \frac{c_C + c_D(\frac{\nu_C}{\nu_D})}{\nu_C(\overline{w}_n - \underline{w}_n) + c_C + c_D(\frac{\nu_C}{\nu_D})}. \tag{16}$$

This must be true so long as $\overline{w}_m - \underline{w}_m > \overline{w} - \underline{w}$, a condition we will return to below.

Now let us turn to the incentive compatibility constraints. Holding constant $C$'s beliefs and strategies, the less martially effective type receives $\nu_D(1 - \overline{x}_{m,e}) - \kappa$ when preparing for war and $\nu_D(1 - \underline{x}_{n,e})$ when deviating from the equilibrium.

Thus incentive compatibility requires $\kappa \leq \underline{\omega}$, where $\underline{\omega} \equiv \nu_D(\underline{w}_n - \overline{w}_m)$. Note that it is possible for $\underline{\omega}$ to be negative, which would ensure that the equilibrium cannot hold.

If the more martially effective type engages in military preparations per the equilibrium, he will reject $\overline{x}_{m,e}$ and receive his war payoff, $\nu_C(1 - \underline{w}_{m,e}) - c_D - \kappa$. If he deviates and chooses not to engage in military preparations, he will accept $\underline{x}_{n,e}$ and receive $\nu_C(1 - \underline{x}_{n,e}$.

Thus incentive compatibility requires $\kappa \leq \overline{\omega}$, where $\overline{\omega} \equiv \nu_D(\underline{w}_n - \underline{w}_m)$. Note that $\overline{\omega}$ is strictly positive, unlike $\underline{\omega}$. Thus, provided $\kappa \leq \underline{\omega}$, the incentive compatibility constraints will be satisfied for both types and the equilibrium will hold. □

*Proposition 4*. To evaluate this claim, we need only consider how the relative size of $\hat{q}_{n,e}$ and $\hat{q}_{m,e}$ vary with $m_D$. The larger these thresholds are, the fewer values of $q'_{n,e}$ and $q'_{m,e}$ warrant risking war. Thus, the proposition can be read as stipulating that sufficiently small values of $m_D$ ensure $\hat{q}_{n,e} > \hat{q}_{m,e}$, while larger values of $m_D$ imply $\hat{q}_{n,e} < \hat{q}_{m,e}$.

I noted in the previous proof that $\hat{q}_{m,e} < \hat{q}_{n,e}$ holds so long as $\overline{w}_m - \underline{w}_m > \overline{w} - \underline{w}$, which is equivalent to

$$\frac{e_C m_C}{e_C m_C + \underline{e}_D \beta m_D} - \frac{e_C m_C}{e_C m_C + \overline{e}_D \beta m_D} > \frac{e_C m_C}{e_C m_C + \underline{e}_D m_D} - \frac{e_C m_C}{e_C m_C + \overline{e}_D m_D}, \tag{17}$$

which is itself true iff $m_D < \hat{m}_D$, where

$$\hat{m}_D \equiv \frac{m_C}{\sqrt{\beta}} \frac{e_C}{\sqrt{\underline{e}_D \overline{e}_D}}. \tag{18}$$

Thus, so long as $m_D < \hat{m}_D$, $\hat{q}_{n,e}$ will be greater than $\hat{q}_{m,e}$, indicating that $C$ would risk war under a wider range of conditions when $D$ prepares for war compared to when he does not. When $m_D > \hat{m}_D$, on the other hand, $\hat{q}_{n,e}$ is less than $\hat{q}_{m,e}$, indicating that $C$ risks war under a narrow range of conditions if $D$ prepares for war.

□

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