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A Bargaining Model of War and Peace: Anticipating the Onset, Duration, and Outcome of War

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Introduction

Prior to sending US troops into Kosovo to protect the civilian population from Serbian aggression, then President Clinton carefully considered the possible consequences of deploying the military in such a volatile region. Would Serbia retaliate against the US-led NATO troops, perhaps precipitating another European war? How many American lives would be lost before the belligerents reached a settlement? Would Serbia eventually concede to US demands or would the US and its allies eventually withdraw without achieving their objectives? The US decision, in other words, was predicated on a careful consideration of the probable duration, the likely outcome, and the expected costs of the engagement. Despite this important and straightforward link between the expected consequences of using force and the decision to use force, it is surprising how very little we know about the consequences of war.[1] If we concede that the expected costs, duration, and outcome of war are an important component of the decision to use force, it is particularly problematic that we have spent so much time studying war onset without first addressing questions related to the duration and outcomes of war.

In this article, we have two purposes. First, we want to improve our understanding of the neglected area of war consequences. Questions related to war duration and war outcome are important in their own right and deserve greater attention. Second, we want to extend our understanding of war onset by explicitly incorporating a richer and more detailed assessment of the probable consequences of war. We do so by developing a model of war that incorporates the decision to begin a war as well as the decision to end it.

[1] Scholars have recently recognized this deficit and begun to fill the void. Recent pieces include Bennett and Stam (1998), Reiter and Stam (1998), Smith (1998), Werner (1998), Stam (1999), Goemans (2000), and Wagner (2000).

The article proceeds as follows. First, we informally present and then critique the common model of war that depicts war as a costly lottery between decisively winning and decisively losing the war. We argue that this "Fight to the Finish" model not only provides a poor foundation upon which to understand the onset of war, but it also fails to provide a useful point of departure to address the great variety of types of war observed empirically. Second, we present a model of war that allows the disputants to negotiate even after the war has begun and thus allows for much greater variation in how and when wars end. Third, we present the results of the model. The model not only identifies the conditions that increase the likelihood of war onset but those that impact the likely duration and outcome of war as well. Finally, we present the results of a simulation that help to clarify some of the comparative static results.

While the individual results of the model are important, we maintain that the model makes a broader contribution to our understanding of international conflict. First, the model represents a unified theory of war onset and war termination. We agree strongly with Blainey (1988) and Wagner (2000) that the onset and termination of war are linked. To understand either, we must understand both. By modeling not only the start of war but its termination as well, we take an important step towards a holistic theory of war. Second, the model challenges the common depiction of war as an alternative to politics. We maintain that war is an extension of politics (Clausewitz 1976); politicians use force not to supplant their diplomatic efforts but to support them. By incorporating negotiation opportunities as well as battles into the model, we allow diplomacy to continue throughout the war.

War: An Alternative to or an Extension of Politics?

Although the consequences of war have generally been ignored as a specific area of study, in order to develop models of war onset scholars have been forced to make several assumptions, either implicitly or explicitly, about those consequences. In models of crisis bargaining in which the key question of interest is whether or not the crisis will end peacefully, the outcome "war" is frequently depicted as a fight to the finish with the victor receiving all of the spoils (Morrow 1989, Powell 1990, Bueno de Mesquita and Lalman 1992, Fearon 1994).[2] Powell (1999:45) states this quite clearly: "To simplify the analysis, we will assume that war can end in only one of two possible outcomes. Either S1 prevails by conquering S2 and eliminating it as a military power, or S2 prevails by eliminating S1."

This "fight to the finish" model of war has several limitations. Most obviously, its simplicity ensures that it provides a poor foundation upon which to study questions related to war outcomes. The model presumes that force and diplomacy are substitutes for each other. If the politicians and diplomats are unable to reach a negotiated settlement, then they resort to force to seize by military means that which they could not acquire at the negotiating table. This stark distinction between force and diplomacy, however, seems untenable. Very few wars end with the total defeat of one side. Instead, the vast majority of wars end even though both sides are still capable of fighting. The war ends before one side is vanquished because the belligerents successfully negotiate a compromise settlement—clear evidence that diplomacy continues even after the fighting has begun. A model that excludes a priori any possibility that wars end short of a decisive military victory obviously cannot explain why and when wars end in less extreme outcomes.

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[2] In some instances, war is similarly depicted as a costly lottery but the lottery is interpreted as the disputants' prewar expectations about the final terms of settlement. As Wagner (2000) notes, such a representation of war reveals little because no explanation for those expectations is provided.

The fight to the finish model not only limits our ability to understand the consequences of war, but it may also impede our analysis of war onset. As Wagner (2000) explains, if war ends only when one side is vanquished, then war is an extremely costly gamble. Even in the best-case scenario where the leader ultimately wins, she must pay the significant cost of destroying her enemy. The expectation of such costs likely creates an artificially high barrier to the use of force. If the war can end short of such devastation, then the costs of using force would be much lower. Expectations about the duration of the conflict would drive expectations about the costs of force. If the conflict was expected to be short, perhaps so short that it would likely end even before a "war" as war is commonly understood developed, then the expected costs of using force would presumably be much lower as well. If true, then leaders may be much more willing to resort to force than typically envisioned because the barriers to using force are not as high as often presumed. Failure to consider how expectations about the costs of using force vary thus may compromise our understanding about when leaders are likely to resort to force.

In order to provide a better foundation to answer questions related to both war outcomes and war onset, it is necessary to develop a model of war that allows the disputants not only to negotiate a settlement to *avoid* a war, but to negotiate a settlement to *terminate* the war as well. To this end, we develop a richer, although admittedly still simplistic, model of war that includes the important possibility that the politicians can end the dispute by negotiating a settlement. In the "bargaining and war" model developed below, the onset of war no longer signals the end of diplomacy but a continuation of it (Clausewitz 1976).

The Bargaining and War Model

The "fight to the finish" model is commonly adopted because of its simplicity. War is an extremely complicated process and some simplifying assumptions are obviously necessary. We maintain, however, that a model of war at a minimum must incorporate not only military maneuverings but political machinations as well. We thus include in this model the possibility for the disputants to negotiate a settlement both before and after fighting has begun. Incorporating the possibility of diplomacy in war, however, raises a fundamental puzzle. If the belligerents need not secure a decisive military victory to end the war but can instead terminate the war by negotiating a settlement, why would they be able to reach such an agreement after the fighting has begun if they were unable to do so at an earlier time so as to prevent the conflict in the first place (Fearon 1995, Wagner 2000)? To address this puzzle, we include uncertainty in the model (Fearon 1995). While negotiations may initially fail because the disputants cannot agree on the terms of settlement, they may eventually succeed as the disputants learn about what concessions each side is willing to make.

Although we believe that the possibility of continued diplomacy is fundamental to a model of war, it is also critical to recognize that these negotiations take place against the backdrop of military engagement. We include the military component of the war in the model in two important ways. First, the fighting ensures that failing to reach an agreement is costly. The more time it takes to reach a settlement, the more resources are expended in the war effort. Second, the fact that fighting continues even as the belligerents negotiate also raises the possibility that the war might end, not in a settlement negotiated by both belligerents, but in a decisive military victory. In this case, rather than negotiating a settlement, the victor can impose a settlement on an enemy incapable of further resistance and thus bereft of any bargaining leverage. This possibility creates a risk for both belligerents that shadows any negotiations.

The model has one attacker *A* and one defender *D*. Initially, *A* has benefits B_a and *D* has benefits B_d. Assume that B_a and B_d are completely divisible (for an analysis with non-divisible benefits see Filson and Werner 2000). In addition to his/her benefits, each player also has some military resources. *A* has resources R_a and *D* has resources R_d. Each player's objective is to obtain as many benefits as possible while conserving resources.

Initially, *A*'s utility is $U_a(R_a, B_a)$ and *D*'s utility is $U_d(R_d, B_d)$. Assume that each utility function is increasing, concave, and twice differentiable in both arguments, and that $\frac{\partial^2 U}{\partial B \partial R} \geq 0$. These assumptions imply that each player always wants more resources and more benefits, that the marginal utilities of resources and benefits are diminishing, and that the marginal utility of benefits is increasing in resources and the marginal utility of resources is increasing in benefits. This last condition implies that a disputant's willingness to risk resources in battle is increasing in his amount of resources and decreasing in the size of his benefits.

A *war* consists of an alternating sequence of negotiations and battles. If negotiations succeed, the war ends. If negotiations fail, the disputants fight another battle. In each battle, *D* defeats *A* with probability *d* and loses with probability $1-d$. When the disputants fight they expend resources. The amount of resources lost depends on who wins each battle. Denote the amount of resources available to *A* if she wins the first battle by R_a^w, and the amount available if she loses by R_a^l, where $R_a^w > R_a^l$. Similarly, R_d^w and R_d^l describe the resources available to *D* after winning or losing the first battle. To keep track of multiple wins and losses while allowing the remaining resources to depend on the order of wins and losses we add superscripts as battles are fought. For example, R_a^{wl} represents *A*'s resources after she wins the first battle and loses the second. The model imposes no *a priori* restrictions on the resource losses that occur during fighting other than that a loss is worse than a win. The resources that remain after a series of battles can depend on the initial resources, the order of wins and losses, or anything else that may be relevant. Since empirically resource losses differ across battles and wars, this generality is useful for constructing falsifiable hypotheses about the onset, duration, and outcomes of war.

While the disputants value resources directly, they are also important because they enable them to continue fighting. We incorporate the possibility of a decisive military victory into the game by assuming that the disputants must maintain some minimal amount of resources to continue fighting. The war ends as soon as one side's resources fall below the minimal amount of resources necessary to continue fighting. If both sides' resources are below the minimal amount then the status quo is restored. The bargaining and war game thus may be long, but it cannot be infinite. We assume that if one side is decisively defeated, she relinquishes all claims to her benefits. The disputants' initial resources and the amounts of resources lost with each battle determine the maximum possible duration of the war.

Although in real wars the disputants may be uncertain about of variety of factors, we introduce uncertainty into the model in a simple way in order to obtain precise results. First, we assume that the uncertainty is one-sided; *D* has complete information about *A*, but *A* does not have complete information about *D*. Although it is surely heroic to assume that *D* is completely informed about *A*, a large variety of equilibria exist in bargaining games with two-sided incomplete information, making prediction difficult or impossible.[3] In contrast, the bargaining game we describe has a unique equilibrium. Second, we assume that *A*'s uncertainty about *D* is confined to uncertainty about *D*'s military ability *d* (the probability that *D* wins each battle). All types of *D* are assumed to have the same utility function $U_d(.,.)$; they differ only by their military ability *d*. The value of *d* is known to *D*, but not to *A*.

[3] Fudenberg and Tirole (1992) discuss the complications that arise in dynamic games with two-sided uncertainty.

In general, war in this game can last for any number of battles, but we begin by presenting a simple example in which several assumptions limit the duration of war. The simple example is sufficient to obtain much of the intuition about the main forces affecting the onset, duration, and outcomes of war. Following the analysis of this example, we present results from more general examples using simulation methods. In the simple example, we make the following assumptions:

Assumption 1: *A* can only sustain one battle loss before her resources are insufficient to continue fighting and she must forfeit her benefits. This implies that a second battle can occur only if *A* wins the first battle.

Assumption 2: *D* can only sustain two battle losses before his resources are insufficient to continue fighting. This assumption along with the first implies that if a second battle occurs, it is decisive.

Assumption 3: There are only two types of *D*. One has $d = d_h$ and the other has $d = d_l$, where $d_h > d_l$.

These simplifying assumptions limit the extensive form of the game to that described in Figures 1-3. Figure 1 sets up the environment and describes stage 1, the choices leading up to the first battle. Initially, *A* is uncertain about *D*'s type and believes that *D* is type d_h with probability λ_1 and type d_l with probability $1-\lambda_1$. She either proposes that *D* give up a share of her benefits, $\gamma_1 B_d$, or not. If she makes no proposal war does not start and the game ends; *A*'s utility is $U_a(R_a, B_a)$ and *D*'s is $U_d(R_d, B_d)$. If she makes a proposal then each type of *D* either accepts it or rejects it. If *D* accepts, she gives $\gamma_1 B_d$ to *A* and the game ends; *A*'s utility is $U_a(R_a, B_a + \gamma_1 B_d)$ and *D*'s utility is $U_d(B_d, (1-\gamma_1)B_d)$. If *D* rejects, then *A* updates her belief that

D is type d_h to probability λ_2 (updating is described further below) and either attacks or quits. If she quits, the status quo is maintained and the outcome is the same as if A does not ask for B_d. If A attacks, then Nature determines who wins the first battle. As described above, A wins with probability $1-d$ and loses with probability d. If A loses, then given the above assumptions, she is decisively defeated and must forfeit her benefits to D.

Figure 2 describes stage 2, the choices if A wins the first battle. After observing the battle outcome A updates her beliefs that D is type d_h to probability λ_3. A then proposes that D give up $\gamma_2 B_d$. D faces a situation just like the first stage – he either accepts or rejects the proposal. If D rejects, then A updates her belief that D is type d_h to probability λ_4 and either attacks or retreats. The game differs between stages 1 and 2 only because A's beliefs are different, both players have suffered some loss of resources from the first battle, and A's "quit" option is now an option to retreat. Assumptions 1 and 2 ensure that the second battle is decisive with the winner receiving all of the benefits.

Figure 3 describes stage 3, the choices if A retreats after winning the first battle. If A retreats then D becomes the aggressor: A offers to give up a share of her benefits, $(1-\gamma_3)B_a$, and D either accepts or rejects. If D accepts, he takes $(1-\gamma_3)B_a$ and the game ends. If he rejects, he attacks. If D attacks then a battle occurs as above; the only difference is that now the players fight over A's benefits. The battle that occurs is decisive: if A wins then D quits and if D wins then A gives up her benefits. If D quits, the players each end up with their initial benefits; the only effect of war is that both players have suffered some loss in resources.

The simplest interpretation of the game is that it is a turf war. At the beginning, A can ask for some part of D's turf, and D can either surrender it to A or not. If A attacks then A and D fight over *D*'s turf. If *A* retreats, then *D* can choose to carry the fight over to *A*'s turf; the two parties switch roles and *D* becomes the aggressor. Thus, starting a war is risky for *A* both because she might lose resources without gaining any of *D*'s territory and because she might end up giving up some of her territory to *D*.

Results

In the following subsections, we present several results from the bargaining and war game.[4] The equilibrium concept is a refined version of the Perfect Bayesian Equilibrium (PBE). The PBE requires that both types of *D* play optimally, that *A*'s beliefs are determined using Baye's rule whenever possible, and that *A*'s choices are optimal given her beliefs.[5] We refine the PBE equilibrium in order to eliminate unrealistic off-the-path beliefs (see Fudenberg and Tirole 1992, Mas-Colell et al. 1995). We require that if *A* believes that type d_l refuses with positive probability in a stage then *A* must also believe that type d_h refuses with probability 1 in that stage. This puts a lower bound on λ_2, λ_3, and λ_4 and rules out some perverse PBEs.

War Onset

We begin by identifying the conditions necessary for a war to begin. In the model, three things must happen for war to begin: *A* must make a proposal, *D* must reject it, and *A* must attack *D* upon rejection. If any of these things does not happen, war is avoided. For a war to continue

[4] Due to space concerns, we do not fully characterize the equilibrium. The full characterization is available from the authors upon request.

[5] We restrict our attention to pure-strategy equilibria wherever possible. As a result, the equilibrium strategies are unique, though in cases where both types of *D* agree, a range of beliefs can support *A*'s equilibrium strategy.

past the first battle, similar conditions must again be met: *D* must again reject *A's* proposal and *A* must again attack after rejection. Results 1 and 2 establish that A's threat to attack must be credible in order for war to start.

Result 1: If *A* prefers to retreat rather than attack when $\lambda_4 = \lambda_3$, then in equilibrium both types of defenders always reject any proposal in the second stage. Similarly, if *A* prefers to quit rather than attack when $\lambda_2 = \lambda_1$, then in equilibrium both types of defenders always reject any proposal in the first stage. If both types of *D* reject any proposal, then it does not matter what *A* proposes.

Proof: *D*'s payoff when *A* retreats is always at least $U_d(R_d^l, B_d)$. Therefore, if *A* prefers retreat to attack when $\lambda_4 = \lambda_3$, then both types optimally refuse to give up any B_d. Likewise, *D*'s payoff when *A* quits is $U_d(R_d, B_d)$. Therefore, if *A* prefers to quit rather than attack when her demand is refused and $\lambda = \lambda_2$, then both types optimally refuse to give up any B_d. ***QED***

Result 2: If in equilibrium *A* attacks in stage 1, then if she wins the first battle she is willing to attack in stage 2: *A* never retreats after winning the first battle. Thus, if *A* is unwilling to attack in stage 2, then war never starts.

Proof: If *A* attacks in stage 1 then it must be the case that her expected utility from attacking exceeds $U_a(R_a, B_a)$. If she retreats with probability 1 after winning the first battle then the best possible outcome for *A* is that *D* is unwilling to attack her. In this case, she ends up with $U_a(R_a^w, B_a)$, which is strictly less than $U_a(R_a, B_a)$. When combined with the assumption that if *A loses* the first battle, she retreats and gives up, *A*'s highest possible expected payoff from fighting the first battle is $d_1 U_a(R_a^l, 0) + (1 - d_1) U_a(R_a^w, B_a)$, where $d_1 = \lambda_1 d_h + (1 - \lambda_1) d_l$. For all values of d_1, this payoff is strictly less than *A*'s initial payoff $U_a(R_a, B_a)$. Therefore, it is never a best response for *A* to attack in stage 1 if she knows that she will retreat with probability 1 after winning. ***QED***

The intuition behind these results is straightforward. *A*'s proposal is shadowed by the threat to use force if *D* does not concede. If *A* is unwilling to attack, then *D* has no incentive to make any concessions. What *A* proposes at that point is immaterial. All proposals are rejected. While these results are intuitive and follow in a straightforward fashion from the logic of backwards induction, three implications are particularly interesting.

First, since *A* has the ability to quit or retreat after she learns that *D* has refused her demand, *A*'s threat to attack must be credible not only when the negotiations begin but after negotiations fail as well. This may be a difficult hurdle for *A* to overcome. Each time negotiations fail because *D* rejects, *A* becomes increasingly pessimistic about the type of defender she faces and thus about her chances in future battles. According to Baye's Rule, if *A*'s demand is refused by *D*, then *A* updates her beliefs that $d = d_h$ as follows: $\lambda_2 = \frac{\lambda_1}{r\lambda_1 + q(1-\lambda_1)}$ and $\lambda_4 = \frac{\lambda_3}{r\lambda_3 + q(1-\lambda_3)}$, where r equals the probability that d_h refuses and q equals the probability that d_l refuses. Since $d_h > d_l$, type d_l is willing to make a greater concession to *A* in order to avoid a fight than is d_h: $\gamma_t^h \leq \gamma_t^l$, where γ_t^h and γ_t^l denote the highest value of γ in stage t that is acceptable to type d_h and d_l, respectively.[6] Since

[6] Note that it is possible that there are no values of γ_1^h or γ_2^h that are acceptable to type d_h. Similarly, it is possible that there are no values of γ_1^l or γ_2^l that are acceptable to type d_l. If $d_h(B_a + B_d)$ and $d_l(B_a + B_d)$ exceed B_d by enough then even $\gamma_1 = 0$ and $\gamma_2 = 0$ may be

d_h refuses any demand greater than γ_t^h while d_l refuses any demand greater than γ_t^l, it must also be true that $q \le r$. Since strong defenders are always at least as likely as weak defenders to refuse a settlement, then the weakest defenders tend to be "screened out" as they accept negotiated settlements. This leaves only the stronger defenders as fighting continues.[7]

If A is willing to attack even when she is certain that the defender is the strong type ($\lambda = 1$), then she maintains a credible threat to attack even if negotiations fail. A may be less optimistic about her chances, but she is still willing to fight the next battle. However, if A is willing to attack when $\lambda = \lambda_1$ or when $\lambda = \lambda_3$ but prefers to retreat when $\lambda = 1$, then there may be no pure-strategy equilibrium. If A were to make an offer just acceptable to the weak defender, then the weak defender would accept and the strong defender would reject. If negotiations then failed, A would know for certain that the defender must be the strong type. Knowing this, A would rather quit/retreat than attack. Anticipating A's turn-around if negotiations fail, the weak defender would mimic the strong defender and reject the demand. In this situation, only a mixed

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unacceptable—both types would rather fight. If γ^h and γ^l are well defined, then the inequality, $\gamma_t^h \le \gamma_t^l$, is strict unless both types prefer to give up all of B_d, $\gamma_t^h = \gamma_t^l = 1$.

[7] This dynamic may suggest that the outcome of the war and the duration of the war are linked. Holding other factors constant, attackers become less likely to win a decisive military victory as the war progresses since it becomes more likely that they are facing strong defenders. We know empirically that more often than not, the initiating or attacking state tends to win wars (Wang and Ray 1994, Gartner and Siverson 1996, Reiter and Stam 1999, Stam 1999). The model suggests that when initiators do lose, the war that led to their demise was likely a long one.

strategy equilibrium is possible: *A* attacks with probability p_t and type d_l rejects with probability q_t.[8] Since the weaker defender sometimes rejects *A*'s demand, *A* is unable to update her beliefs about *D*'s type to certainty. If her proposal is rejected, *A* becomes more pessimistic about her chances but not so much that she is unwilling to follow through on her threat to attack. This implies that since *A* must maintain a credible threat to attack for a war to start, one of two things is likely true when wars begin: either the attacker is willing to fight even in the worst case scenario that the defender is very strong or the attacker is initially so confident that the defender is weak that some bad news is not sufficient to dissuade her from attacking.

The second implication follows from Result 2. Result 2 shows that for *A* to be willing to fight the first battle, she must also be willing to fight the last battle as well. If *A* anticipates that she will eventually retreat, the game unravels. *A* anticipates that if she fights in the first stage then the negotiations that follow will fail and she will be forced to retreat. Rather than pay the costs of fighting in the first stage simply to retreat when negotiations inevitably fail, she retreats immediately. *A*'s unwillingness to fight to the end prevents her from credibly threatening to attack initially.

In more complex examples in which *A* might sustain several losses before conceding her benefits, *A* need not be willing to fight every battle in order to credibly threaten to attack initially, but she does need to be willing to fight to the end at least when the tide of battle is in her favor. Just as *D*'s response to her demands provides *A* with information so too do battle

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[8] It turns out that in the mixed strategy equilibrium only type dl uses a mixed strategy. Type dl's probability of rejecting ensures that when A updates her beliefs she is indifferent between attacking and retreating, but in equilibrium A attacks with probability 1. Details are available from the authors upon request.

outcomes.[9] According to Baye's rule, *A* updates her beliefs that $d = d_h$ as follows:

$\lambda_3 = \frac{(1-d_h)\lambda_2}{(1-d_h)\lambda_2 + (1-d_l)(1-\lambda_2)}$. Since $d_h > d_l$, then λ_3 must be less than λ_2: *A*'s victory makes her more optimistic about *D*'s type and thus more optimistic about the outcomes of future battles. Conversely, after each battle loss, *A* becomes less optimistic about *D*'s type and thereby less optimistic about the outcomes of future battles. If *A* anticipates that she will eventually retreat even in the best-case scenario where she is winning, than it is in her best interest not to fight at all. Since fighting is costly, limited probes are unlikely. Only if the attacker is losing are we likely to see her pulling back or retreating.

The final implication deals with the relationship between force and diplomacy. Results 1 and 2 show that the distinction frequently drawn between the use of force and diplomacy is a false one. *D* only agrees to concede some of his benefits because he anticipates that if he does not, *A* will resort to force. If *D* anticipates that *A* will withdraw rather than attack, both types of *D* refuse to make any concessions and negotiations fail. In this model the success of diplomacy rests on the credible threat of force.

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[9] The fact that the attacker learns not only from the defender's response but the battle outcomes as well is an important and realistic component of the model. Nothing was more revealing about the capacity of the Iraqi military—a key source of uncertainty in the Gulf War, for instance, than the actual failure of Iraq's air defense systems, the repeated inaccuracy of her skud missile attacks, and the ease with which the allies' launched their ground offensive. As the war was fought, the allies were able to revise their assessment of their opponent and to alter their negotiating stance accordingly. The war itself provided the information that was previously lacking.

Whether or not *A* is willing to fight each battle is clearly central to whether or not a war begins. What conditions must be satisfied for *A* to be willing to attack? Results 3 and 4 identify the conditions that make it more likely that *A* will attack if negotiations fail.

Result 3: If there is no proposal that is acceptable to type d_l then *A* is unwilling to attack.[10] Thus, if *A* anticipates that she will have to fight regardless of what proposal she makes, then the war never starts.

Proof: We prove this for stage 2. A similar logic applies in stage 1. If there is no proposal that is acceptable to type d_l in stage 2, then in stage 1 when *A* is deciding whether to attack she knows that she obtains $B_a + B_d$ if she wins two battles and loses B_a otherwise. Her probability of obtaining $B_a + B_d$ is $(1-d_2)(1-d_3)$, where $d_2 = \lambda_2 d_h + (1-\lambda_2)d_l$ and $d_3 = \lambda_3 d_h + (1-\lambda_3)d_l$, where λ_3 is defined above. Substitute for λ_3 and simplify to show that $(1-d_2)(1-d_3) = (1-d_h)^2\lambda_2 + (1-d_l)^2(1-\lambda_2)$, which must be strictly less than $(1-d_l)^2$, which must be strictly less than $(1-d_l)$. Now if there is no proposal that is acceptable to type d_l, then it must be the case that $B_d < d_l(B_a + B_d)$ which implies that $B_a > (1-d_l)(B_a + B_d)$. Thus, given that $(1-d_2)(1-d_3) < 1-d_l$ and given that *A*'s utility function is concave, *A* is strictly better off with B_a then she is with a lottery that pays $B_a + B_d$ with probability $(1-d_2)(1-d_3)$ and 0 otherwise. *A* does not sacrifice resources to obtain expected benefits that are lower than her initial benefits. ***QED***

[10] There may be no proposal acceptable to d_l if his expected gain from fighting is high enough (see footnote 5).

Result 3 suggests an important relationship between the possibility of war and whether or not there is a disparity between the players' distribution of power and their distribution of benefits (Powell 1999, Werner 1999). D's unwillingness to concede and commitment to fighting arises directly from a gap between what he has and what he thinks he can get. *D* is willing to refuse all demands only if $B_d < d_l(B_a + B_d)$. Rearranging terms shows that it is only possible for *D* to be committed to fighting when $\frac{B_d}{(B_a + B_d)} < d_l$, or *D*'s proportion of the available benefits is less than his probability of victory.[11] If *d* generally indicates the distribution of power between the disputants, then *D*'s willingness to fight is driven by a disparity between the distribution of power and the distribution of benefits: *D* refuses to make any concessions because what he currently has is already less than what he thinks he deserves given his power relative to *A*. If *D* has less than he deserves given his power, this implies that *A* must have more than she "deserves": $\frac{B_a}{(B_a + B_d)} > (1 - d_l)$. Since *A* is advantaged by the status quo, *A* is better off laying low, keeping her current benefits of B_a and not challenging *D*.

Reversing the situation provides conditions ripe for an assault by *A*. If the status quo favors *D* such that *D*'s share of the benefits exceeds his share of power, then *D* does not expect that he could successfully defend his current share of the benefits if a war were to start. If challenged, he would be willing to make some concessions rather than fight a war he expects to

[11] *D* is only potentially committed to battle under these conditions because it may be the case that his costs are sufficiently high that he is willing to make some concessions even though he does not expect to lose any territory if he were to fight. *D* cannot be committed to battle, however, if this condition is not fulfilled.

lose (the amount he is willing to give up is discussed below). While *D* is advantaged by the status quo, *A* is disadvantaged. The discrepancy between the distributions of power and benefits creates a situation in which *A* believes that war would provide her a greater share of the benefits at stake. War of course does not necessarily follow. Despite her dissatisfaction with the distribution of benefits, *A* may still be unwilling to fight because of the anticipated costs of battle. The disputants may also avoid war if *D* is willing to make the concessions demanded by *A*. *A*'s dissatisfaction with the status quo, however, is a necessary (if not sufficient) condition for war.

This result addresses two long-standing debates in the discipline regarding the relationships between the possibility of conflict and the distribution of power and the possibility of conflict and the value of the status quo (see Powell 1999 and Werner 1999 for reviews). If a discrepancy between the distributions of power and benefits creates a permissive condition for conflict, then the relationships between the probability of conflict, the distribution of power, and the value of the status quo are interconnected. A state may be willing to attack even if her probability of success is low if her share of the available benefits is even lower. This may explain why some small states are sometimes willing to take on much larger adversaries. The degree to which there is a discrepancy between the distribution of power and the distribution of benefits also provides a useful way to define the elusive notion of state dissatisfaction (see also Powell 1999). While dissatisfaction with the status quo has long been identified as a critical component of war, it has been difficult to determine either analytically or empirically which states are dissatisfied.[12]

[12] Power transition theorists, in particular, have focused productively on the importance of dissatisfaction to the risk of war (for a review see Kugler and Lemke 1996).

Result 4 identifies how different parameters affect whether or not *A* is willing to attack and thus affect the possibility of war.

Result 4: If B_d is sufficiently high and *A*'s anticipated resource losses are sufficiently low, then in equilibrium *A* is willing to attack. If B_d is sufficiently low and *A*'s anticipated resource losses sufficiently high, then in equilibrium *A* retreats/quits. Further, if d_l is sufficiently high then *A* retreats/quits. *A* is more likely to be willing to attack if *D*'s anticipated resource losses are small.

Proof: As long as *A*'s resources are not driven below the minimum necessary to fight a battle, as B_d rises eventually the expected utility from attacking must exceed the expected utility from retreating/quitting because $U_a(.,.)$ is an increasing function. At the other extreme, if B_d is small and *A*'s anticipated resources losses sufficiently large then *A* prefers to retreat/quit. To determine the effect of d_l note that if $d_l = 1$ then d_h must also equal 1, and in this case if *A* attacks in stage 1 he gets $U_a(R_a^l, 0)$ but if she quits she gets $U_a(R_a, B_a)$, which is strictly higher. This implies that if d_l is sufficiently high then *A* prefers to quit.[13] To determine the effect of *D*'s anticipated resource losses note that if *D*'s anticipated losses fall then *A*'s payoff from retreating falls because γ_3^h and γ_3^l fall and her payoff from attacking does not change. ***QED***

These results show that what is at stake as well as the anticipated costs of war critically affect whether or not *A* can credibly threaten to attack. Fighting each battle rather than quitting or retreating involves risk. If the potential benefits are great enough, then *A* is willing to attack

[13] Similarly, in stage 2, if *A* attacks he gets $U_a(R_a^{wl}, 0)$ but if she retreats he gets $U_a(R_a^w, \gamma_3^h B_a)$, which is strictly higher. This implies that if d_l is sufficiently high then *A* prefers to retreat rather than attack in stage 2.

even if the probability of winning is low. Similarly, if the anticipated costs of fighting are sufficiently low then *A* is willing to attack despite the risk involved. Perhaps surprisingly, *D*'s anticipated resource losses also influence *A*'s willingness to attack. Whereas it is commonplace to assert that the expectation of high costs acts as a deterrent to conflict, it is generally assumed that the disputant's own costs are the critical factor. Here, the defender's anticipated costs also influence *A*'s willingness to fight because they impact what proposal is acceptable to *D*. The larger *D*'s anticipated costs, the more concessions *D* is willing to make and the less attractive attacking looks in comparison. The anticipated costs of conflict are important not only because they make fighting less attractive but because they can make the negotiated settlements more attractive as well. While Result 4 provides some intuition about the effects of the parameters on the onset, duration, and outcomes of war, it applies when parameters are either high or low. It is difficult to obtain general results on the effects of changing parameters for much of the intermediate ranges. The reason why is that when *A* is deciding whether to attack or retreat in stage 2, she compares the expected utility from attacking to the expected utility of retreating, and changing the parameter values tends to change *A*'s payoffs from attacking and retreating in the same direction. For example, as the probability that *D* wins a fight rises, *D* requires more benefits in order to agree in the retreat continuation and is more likely to win a battle if attacked. These effects cause *A*'s payoffs from attacking and retreating to both fall; the net impact on *A*'s decision to attack or retreat is not clear. Given the difficulties of obtaining precise analytical results, either an empirical analysis or a simulation must be used to sort out the comparative statics. We provide simulation results below.

Conflict Termination

While a war cannot start if *A* is unwilling to attack, *A*'s willingness to attack does not necessarily mean that a war will occur. The disputants' ability to negotiate a settlement provides the means to avoid the war even when *A* is ready to fight. Likewise, if the disputants initially fail to reach a settlement and a war does begin, their ability to reach a negotiated settlement later provides the means to terminate the war. Wars terminate or are avoided when *A* makes a proposal that the defender accepts. What proposals *A* makes thus determines when war ends.

Recall that γ_t^h and γ_t^l denotes the highest values of γ_t acceptable to types d_h and d_l, respectively, in stage t. If γ_t^h and γ_t^l are well defined such that there are values of γ_t^h and γ_t^l that are acceptable to d_h and d_l, then the values of γ_t^h are determined as follows. In stage 3, d_h accepts *A*'s proposal after *A*'s retreat if:

$$U_d(R_d^l,(1-\gamma_3)B_a+B_d)\geq d_h U_d(R_d^{lw},B_a+B_d)+(1-d_h)U_d(R_d^{ll},B_d)\,. \tag{1}$$

In stage 2: d_h accepts *A*'s proposal after *A* wins the first battle if:

$$U_d(R_d^l,(1-\gamma_2)B_d)\geq p_2[(1-d_h)U_d(R_d^{ll},0)+d_h U_d(R_d^{lw},B_d+B_a)]+(1-p_2)U_{dh3}\,, \tag{2}$$

where p_2 denotes the probability *A* attacks and U_{dh3} denotes d_h's continuation utility if *A* retreats. In stage 1, d_h accepts *A*'s proposal if:

$$U_d(R_d,(1-\gamma_1)B_d)\geq p[d_h U_d(R_d^w,B_a+B_d)+(1-d_h)U_{dh2}]+(1-p)U_d(R_d,B_d)\,, \tag{3}$$

where p denotes the probability *A* attacks and U_{dh2} denotes d_h's continuation utility if *A* attacks and wins the battle. The values of γ_t^l are determined similarly. Simply replace d_h with d_l and U_{dht} with U_{dlt}.

Since $d_h > d_l$, d_l is willing to make a greater concession to *A* in order to avoid a fight than is d_h: $\gamma_t^h \leq \gamma_t^l$. The inequality is strict unless both types are willing to give up all of $B_d : \gamma_t^h = \gamma_t^l = 1$. This implies that (1) any proposal less than or equal to γ_t^h is acceptable to both types, (2) any proposal greater than γ_t^h but less than or equal to γ_t^l is acceptable to type d_l but unacceptable to type d_h; and (3) any proposal greater than γ_t^l is unacceptable to both types. Since more benefits are better than less, *A* never asks for less than that with which she can get away. As a result, there are at most three relevant options for *A* in each stage: propose γ_t^h, propose γ_t^l, or ask for more than γ_t^l. The conflict ends as soon as *A* demands γ_t^h, may either continue or end if *A* proposes γ_t^l (depending upon whether the defender is type d_l or type d_h), and definitely continues if *A* demands more than γ_t^l.

Results 5 and 6 identify the conditions for conflict termination by identifying the conditions under which *A* makes the different proposals.

Result 5: In equilibrium, *A* never provokes a fight with both types. At each negotiating opportunity, if type d_l remains then *A* prefers proposing γ_t^l to proposing any $\gamma_t > \gamma_t^l$. Similarly, if type d_h is the only type left, *A* prefers proposing γ_t^h to proposing any $\gamma_t > \gamma_t^h$.

Proof: We prove this for *A*'s decision in stage 3 (the subgame that occurs after A retreats). Proofs for *A*'s decisions in stages 1 and 2 are similar and are omitted. To see why *A* never provokes a fight with both types in equilibrium, first note that if $\gamma_3^l = 1$ so that type d_l is willing to allow A to retain all of B_a rather than fight, *A* is unable to provoke a fight. If $\gamma_3^l < 1$ then if *A* prefers proposing some $\gamma_3 > \gamma_3^l$ to proposing γ_3^l, then it must be the case that

$$d_l U_a(R_a^{wl},0)+(1-d_l)U_a(R_a^{ww},B_a)\geq U_a(R_a^{w},\gamma_3^l B_a).$$

However, by Jensen's inequality (which states that for concave functions $U_d(E(x))\geq E(U_d(x))$, where $E(.)$ represents the expectation operation and x represents a random variable) and the fact that R_a^{wl} and R_a^{ll} are both less than R_a^{w},

$$d_l U_a(R_a^{wl},0)+(1-d_l)U_a(R_a^{ww},B_a)<U_a(R_a^{w},(1-d_l)B_a),$$

which, when combined with the fact that $(1-\gamma_3^l)<d_l$ (proven below in Result 7), implies that $d_l U_a(R_a^{wl},0)+(1-d_l)U_a(R_a^{ww},B_a)<U_a(R_a^{w},\gamma_3^l B_a)$. Therefore, it cannot be the case that *A* prefers to propose some $\gamma_3>\gamma_3^l$. A similar argument establishes that $d_h U_a(R_a^{wl},0)+(1-d_h)U_a(R_a^{ww},B_a)<U_a(R_a^{w},\gamma_3^h B_a)$. Since *A* always prefers the settlement to fighting type d_h for certain, then *A* proposes γ_3^h if type d_h is the only type left. ***QED***

Result 5 offers an important insight into the causes of war. War does not occur because *A* is simply aggressive and doggedly committed to fighting. *A* always makes a proposal that some type of defender will accept. Wars occur in this model only when *A* gambles that the defender is the weak type and makes a proposal that only the weaker defender accepts. If the defender is the strong type, then he refuses and a war begins. Further, note that wars do not start because the *defender* is doggedly committed to fighting. *D* fights, not because he is unwilling to make any concessions but because he is unwilling to make as large a concession as *A* demands.[14] *D* fights because he prefers the risky battle outcome to *A*'s excessive demand. War is a product of *A*'s willingness to endure the risk of fighting in order to obtain a better settlement and *D*'s

[14] It is thus too simplistic to conclude that both sides must anticipate victory for a war to be rational (Blainey 1988).

expectation that by fighting he can demonstrate that he deserves a better settlement than previously proposed.

Result 6 highlights the conditions that make it more likely that *A* will risk starting or continuing a war by offering γ_t^l rather than γ_t^h.

Result 6: *A* is more likely to propose $\gamma_t = \gamma_t^l$ if she is optimistic that *D* is type d_l, if she anticipates low resource losses from fighting, and if d_l is low.

Proof: We again prove this for *A*'s decision in stage 3. Proofs for *A*'s decisions in stages 1 and 2 are similar and are omitted. Given that *A* never demands $\gamma_t > \gamma_t^l$, *A*'s expected utility in the continuation following her retreat, U_{a3}, can be expressed as follows:

$$U_{a3} = \max\{U_a(R_a^w, \gamma_3^h B_a), \\ \lambda_4[d_h U_a(R_a^{wl}, 0) + (1-d_h)(U_a(R_a^{ww}, B_a)] + (1-\lambda_4)(U_a(R_a^w, \gamma_3^l B_a)\} \quad (4)$$

In the first branch, *A* proposes $\gamma_3^h B_a$, both types accept, and a battle does not occur. In the second branch *A* proposes $\gamma_3^l B_a$, type d_l accepts and type d_h refuses and fights. Expression 1 establishes that changing λ_4, R_a^{wl}, and R_a^{ww} has no effect on γ_3^h and γ_3^l. Given this, partial derivatives can be used to show that decreasing λ_4, and increasing R_a^{wl} and R_a^{ww} increases the value in the second branch of expression 4 without changing the value in the first branch. Therefore, *A* will be more likely to propose γ_3^l if λ_4 and *A*'s anticipated resource losses are low. By expression 1, decreasing d_l does not change γ_3^h but increases γ_3^l. Therefore, *A* will be more likely to propose γ_3^l if d_l is low. ***QED***

This result is intuitive once *A*'s settlement proposals are viewed in terms of a risk-return tradeoff. Expression 4 demonstrates that *A* can either choose to get $\gamma_3^h B_a$ for certain or risk continuing the war in order to get the more favorable settlement of $\gamma_3^l B_a$. Whether or not *A* chooses the safe, but less favorable, settlement option or the risky, but more favorable, settlement option depends upon how *A* assesses the value of the gamble. The more confident *A* is that the defender is the weak type, the less risky it seems to make a tough demand. A less optimistic attacker is more cautious and is thus more likely to make moderate demands in order to reduce the possibility of war against the stronger defender. It is thus not surprising that many have noted that when wars do start, the attacker often seems very confident of victory (Blainey 1988). *A*'s beliefs can change throughout the war, however, as she learns from both *D*'s responses and from battle outcomes. Since *A* generally becomes more pessimistic each time negotiations fail, we should expect a general tendency for attackers to propose terms acceptable to the stronger defenders as the war continues: war becomes more likely to end the longer it has endured.[15] In addition, since battle victories make *A* more optimistic about the defender's type while battle losses make her less optimistic, we should expect that she is more likely to offer an acceptable settlement after a loss than after a victory. Thus, wars in which the attacker is losing should tend to be shorter than if she is winning.

We also expect that early losses for the attacker are particularly conducive to a short war. Compare two wars where both are at the same stage *t*. Suppose that prior to *t* each war has the same number of wins and losses for *A*, but that in war 1 the losses occurred early on and in war 2 the wins occurred early on. If the lowest type of defender still active in each war is the same , and assuming that the equilibrium involves only pure strategies, then by Baye's rule *A*'s beliefs at stage *t* are the same in each war and the continuations are identical. However, it is likely that

[15] The evidence of whether or not wars are duration dependent is mixed. See Vuchinich and Teachman (1993) and Bennett and Stam (1996).

the lowest type still active in war 1 is a stronger type, because early losses make *A* pessimistic, and this makes *A* more likely to make less demanding proposals – thus, more types of defenders accept proposals early on. This contributes to *A*'s pessimism further, because if the lowest type still active at stage *t* in war 1 is a stronger type then *A* must be more pessimistic at stage *t* in war 1, and as a result is more likely to make a proposal that will be accepted by the strong types. Thus, war is likely to end sooner when *A* sustains early losses. The gamble of making the tough demand also seems less risky the lower the anticipated costs of fighting. Unless *A* risks running out of resources, *A* knows that she can modify her demands when the fighting stops and the disputants return to the negotiation table. The costs of fighting are thus the penalty she must pay for attempting to get the better deal initially. The higher the penalty, the less likely *A* will want to pay it. The potential reward of gambling with the tougher demand also impacts *A*'s willingness to take the gamble. The more concessions the weak defender is willing to make, the better the return if the gamble actually pays off. Anticipating a large reward if the gamble pays off, *A* is willing to accept the risk of war.

The Terms of Settlement

If and when negotiations do succeed, what are the terms of settlement? To some degree, the outcome of a war is unpredictable. The war began because *A* did not know for certain which defender she faced and thus which terms were acceptable. In addition what *D* is willing to accept depends in part on the history of the war and we cannot anticipate battle outcomes with certainty. We can, however, identify the parameters that impact what both types of *D* are willing to accept and thus generally determine how the terms of settlement might vary between conflicts. Result 7 establishes that *D* is willing to concede more of the benefits during the negotiations than he expects he will have to concede in battle. Result 8 identifies the parameters that affect the size of the concession *D* is willing to make (in stages 1 and 2) or accept (in stage 3).

Result 7: The minimum amount of B_a in stage 3 that type d_h must obtain in order to not attack after *A* retreats, $(1-\gamma_3^h)B_a$, is less than the expected amount that type d_h would obtain by fighting, $d_h B_a$. Similarly, if *A* attacks with probability 1 in stage 2 and γ_2^h is well defined, then the minimum amount of B_d type d_h must retain in order to agree, $(1-\gamma_2^h)B_d$, is less than the expected amount that type d_h would retain by fighting, $d_h(B_d + B_a)$. There is a similar relationship in stage 1. Similar relationships hold for type d_l: $(1-\gamma_3^l)B_a < d_l B_a$ and $(1-\gamma_2^l)B_d < d_l(B_d + B_a)$.

Proof: Consider the negotiating position of type d_h in stage 3. First note that if $\gamma_3^h = 1$ then the result holds because $d_h > 0$. If $\gamma_3^h < 1$, then

$$U_d(R_d^l, (1-\gamma_3^h)B_a + B_d) = d_h U_d(R_d^{lw}, B_a + B_d) + (1-d_h)U_d(R_d^{ll}, B_d).$$

Note that if type d_h fights she receives benefits $B_a + B_d$ with probability d_h and benefits B_d with probability $1-d_h$. Given this, her expected amount of benefits is $d_h B_a + B_d$. By Jensen's inequality, $U_d(R_d^l, d_h B_a + B_d) \geq d_h U_d(R_d^l, B_a + B_d) + (1-d_h)U_d(R_d^l, B_d)$. Given that R_d^{ll} and R_d^{lw} are both less than R_d^l, this implies that

$U_d(R_d^l, d_h B_a + B_d) > d_h U_d(R_d^{lw}, B_a + B_d) + (1-d_h)U_d(R_d^{ll}, B_d)$. Because the right-hand side of this inequality is equal to $U_d(R_d^l, (1-\gamma_3^h)B_a + B_d)$, this inequality implies that $(1-\gamma_3^h)B_a < d_h B_a$. A similar argument establishes that $(1-\gamma_3^l)B_a < d_l B_a$. The method of proof to establish

$(1-\gamma_2^h)C_d < d_h(B_d + B_a)$ and $(1-\gamma_2^l)B_d < d_l(B_d + B_a)$ is the same. For brevity we omit the details. A similar logic applies to stages 1 and 2 and is omitted for the sake of brevity. ***QED***

Result 8: The minimum amount of benefits in stage 3 that type d_h must obtain in order to not attack after *A* retreats, $(1-\gamma_3^h)B_a + B_d$, is weakly increasing in d_h, B_a, and B_d and weakly decreasing in *D*'s anticipated resource losses. Similarly, if *A* attacks with probability 1 in stage 2, then the minimum amount of benefits in stage 2 that type d_h must retain in order to agree, $(1-\gamma_2^h)B_d$, is weakly increasing in d_h, B_a, and B_d and weakly decreasing in *D*'s anticipated resource losses. There is a similar relationship in stage 1.Similar results hold for type d_l.

Proof: Consider the incentives of type d_h in stage 3. Let $\Delta_w = R_d^l - R_d^{lw}$ and $\Delta_l = R_d^l - R_d^{ll}$ represent *D*'s anticipated resource losses. If $\gamma_3^h = 1$, then changes in d_h, B_a, B_d, Δ_w, and Δ_l may be inframarginal and have no effect on γ_3^h. If $\gamma_3^h < 1$ then $U_d(R_d^l, (1-\gamma_3)B_a + B_d) = d_h U_d(R_d^{lw}, B_a + B_d) + (1-d_h)U_d(R_d^{ll}, B_d)$. Partial derivatives can be used to show that the right-hand side is increasing in d_h, B_a, and B_d and decreasing in Δ_w and Δ_l. Therefore, as d_h, B_a, and B_d rise or as Δ_w and Δ_l fall, $(1-\gamma_3^h)B_a + B_d$ must rise in order to maintain the equality. The method of proof to establish the parameter effects on $(1-\gamma_2^h)B_d$ and $(1-\gamma_1^h)B_d$ is the same. For brevity we omit the details. ***QED***

The intuition behind these results is straightforward. *D*'s willingness to make concessions at the negotiating table depends on what he believes will happen if negotiations fail and fighting continues. The better the diplomats expect the generals to do, the fewer concessions the diplomats are willing to make. Similarly, the more valuable the benefits that may be taken by force, the less willing *D* is to give them up during negotiations. In this game, since the negotiators' positions are driven by what they expect to happen if negotiations fail and fighting continues, negotiated settlements are not necessarily any "fairer" than military decisions.[16] They are, however, more efficient because resources are not needlessly expended during battle.

Although expectations about future battle losses and victories determine in large part *D*'s position during negotiations, note that *D* is willing to concede more than that which he expects the generals could obtain by force. *D*'s desire to avoid the costs of fighting as well as his desire to avoid the risks of battle ensure that he is more amenable to compromise than his military abilities might indicate. Even if *D* wins future battles, he must expend resources. Since he values his resources as well as his benefits, he is willing to give up some of his expected benefits in order to avoid the costs of fighting. The greater the anticipated costs, the more *D* is willing to compromise. The risks inherent to war also encourage *D* to accept less at the negotiating table than he expects to gain from fighting. A risk-averse defender is willing to compromise on the settlement in order to avoid the uncertainty associated with a military decision. While the costs and risks of war are often identified as a deterrent to fighting, more specifically the anticipated costs of and the risks associated with war help the disputants to avoid war by making the disputants more willing to compromise during negotiations.

Simulation Results

The above discussion describes the model's comparative statics for a relatively simple case. In this section, we explore the model further using simulation methods. Assumptions 1-3 made above are abandoned: the simulation program puts no constraints on the maximum number of battles or the number of types. Once war starts, if *A* continues to attack and *D* does not accept

[16] This perspective on negotiated settlements differs from the view often espoused about the benefits of negotiated settlements over military victories (see Werner 1999 for a review).

any proposal then war over B_d continues. If *A* retreats and *D* refuses her proposal, then war over B_a occurs. War continues until one player gives up or no one is willing to attack. Assume that a player with no resources cannot attack or defend, so the war cannot last longer than it takes for one of the players to run out of resources. The war typically ends sooner because *D* agrees to one of *A*'s proposals.

The simulation results demonstrate that the model accommodates a wide variety of patterns depending on the size of the benefits, the initial resources of each side, the resource losses that are anticipated to occur in each battle, the military ability of each type, and the degree to which *A* is optimistic about *D*'s type. The results show that the model can generate equilibria with no war and the preservation of the status quo, war with several battles, an instant settlement, a battle followed by a settlement, or a battle followed by a retreat and a return to the status quo.

In all of the results presented here the following utility functions are used:

$$U_a(R,B) = R^{\alpha_a}(\beta_a + B)^{(1-\alpha_a)}$$

$$U_d(R,B) = R^{\alpha_d}(\beta_d + B)^{(1-\alpha_d)},$$

where $\alpha_a = 0.1$, $\alpha_d = 0.1$, $\beta_a = 0.5$, and $\beta_d = 0.5$.

We start from a base case with the following parameters: $B_a = 20$, $B_d = 20$, $R_a = 5$, and $R_d = 5$. Each victory costs a player one unit of resources and each loss costs the player one and a half units of resources, so $R_a^w = 4$, $R_a^l = 3.5$, $R_a^{ww} = 3$, $R_a^{wl} = 2.5$, etc. In the base case there are five types of *D*:

$$\{d_1, d_2, d_3, d_4, d_5\} = \{.40,.45,.50,.55.60\}.$$

A's priors have a uniform distribution:

$$\{\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5\} = \{\frac{1}{5}, \frac{1}{5}, \frac{1}{5}, \frac{1}{5}, \frac{1}{5}\}.$$

Note in the base case both players have benefits of the same size and the same level of resources, and if *A* fought a battle with the average defender then A would win with probability .5. In the base case in equilibrium *A* does not ask for B_d in stage 1 so war never starts. In what follows, we consider the effects of changing the parameters on the equilibrium. The outcomes of conflict are to some extent random simply because battle outcomes are random, and this implies that the same initial underlying conditions can lead to a variety of outcomes. We describe all of the possible outcomes in each case.

First consider what happens if $B_a = 2$ while all of the other parameters take their base-case values. This represents the case in which the two players are evenly matched in terms of resources but the attacker has fewer benefits. In this case in equilibrium *A* proposes $\{B_a + .63B_d, .37B_d\}$. The only type that accepts this proposal is type d_1. The others refuse, and after a refusal *A* attacks. If *A* wins the first battle, she proposes $\{B_a + .73B_d, .27B_d\}$ and all types accept except type d_5. After a refusal, which occurs only if *D* is type d_5, *A* attacks again. If she wins the second battle she proposes $\{B_a + B_d, 0\}$ and *D* accepts. If *A* loses the first battle she proposes $\{B_a + .24B_d, .76B_d\}$ and all types accept except type d_5. After a refusal, *A* attacks. If *A* wins the second battle she proposes $\{B_a + .46B_d, .54B_d\}$ and *D* accepts. If *A* loses the second battle, she retreats and proposes the status quo $\{B_a, B_d\}$ and *D* accepts.

Interestingly, for a considerable range of benefit values, scaling the benefits upward while keeping the distribution at a 1:10 ratio leads to the same strategies as in this case. Scaling the benefits downward leads to the same strategies for some range, but once the benefits become small enough the equilibrium changes. For example, when $B_a = .01$ and $B_d = .10$, in stage 1 *A* proposes $\{B_a + .43B_d, .57B_d\}$ and all types accept.

Case 1 establishes that an imbalance of benefits when the distribution of power is perceived to be equal leads to redistribution. If the stakes are relatively small then an agreement occurs without a war, but if the stakes are high then a fight is more likely to occur. Note that if war starts then the battle outcomes influence subsequent proposals. If A wins the proposals become more demanding and if A loses the proposals become less demanding. Two early losses lead to retreat and the restoration of the status quo. This does not occur because D is no longer capable of fighting – it occurs because D is unwilling to risk resources to obtain A's small benefits.

Now consider what happens if the benefits are equal but *A* is stronger than *D*. If *A* has more resources than *D* she can last longer if they fight. Suppose that $R_a = 7$ and all other parameters take on their base-case values. In this case, in stage 1 *A* proposes $\{B_a + .68B_d, .32B_d\}$. Types d_1, d_2, and d_3 agree and the others refuse. After a refusal *A* attacks. If *A* wins the first battle she proposes $\{B_a + .85B_d, .15B_d\}$ and both remaining types accept. If *A* loses the first battle, she proposes $\{B_a + .47B_d, .53B_d\}$ and both remaining types accept. Increasing A's initial resources more makes the conflict even more one-sided – if $R_a = 10$ and all the other parameters take on their base-case values then in stage 1 *A* proposes the re-division $\{B_a + B_d, 0\}$ and all types agree.

In the second instance, the disputants' benefits and resources are equal but *A* is more optimistic about *D*'s type and thus expects that she has a greater than equal chance of winning each battle. Suppose $\{\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5\} = \{\frac{2}{3}, \frac{1}{6}, \frac{1}{12}, \frac{1}{24}, \frac{1}{24}\}$. In equilibrium in stage 1 *A* proposes $\{B_a + .25B_d, .75B_d\}$. Type d_1 accepts and the others refuse. After a refusal *A* attacks. If *A* wins the first battle she proposes $\{B_a + .35B_d, .65B_d\}$. Type d_2 accepts and the others refuse. After a refusal *A* attacks. If *A* loses the second battle, she retreats and proposes the status quo, which all types accept. If *A* wins the second battle she proposes $\{B_a + .52B_d, .48B_d\}$. Types d_3 and d_4 accept and type d_5 refuses. After a refusal *A* attacks again. If *A* wins the third battle, she proposes $\{B_a + B_d, 0\}$ and *D* agrees. If *A* loses the third battle she retreats and proposes the status quo, which *D* accepts. If *A* loses the first battle, she retreats and proposes $\{.91B_a, .09B_a + B_d\}$. Type d_2 agrees but the others refuse and attack. If *A* wins the second battle she proposes the status quo and *D* accepts. If *A* loses the second battle she proposes $\{.61B_a, .39B_a + B_d\}$ and *D* accepts. In this instance, the war endures when *A* severely miscalculates her opponent. The war can last because *A* was initially confident that she was facing a weak defender but was in fact confronting a much stronger defender. While *A* learns from *D*'s refusal and from her battle losses, her initial optimism ensures that the learning process is slower than if she was not so confident originally.

These last cases demonstrate that a perceived imbalance of power when the benefits are balanced leads to re-distribution. *A* always makes a demand in this instance. Whether or not a war follows and how long the war lasts depends on much the defender believes she must concede, if anything. The stronger the defender actually is, the more likely a war will start and the less likely the war will end quickly. Together these cases provide important evidence that a perceived disparity between the distributions of power and benefits coupled with some uncertainty about how large that disparity might be is a potent source of conflict.

Conclusion

This model, although already fairly complex, should be viewed as only a starting point to understand the process of war onset and war termination. There are many factors that likely impact how the disputants' negotiate and fight that are not included in this model. Most notably, the model is devoid of any domestic political considerations. In this model, we assume that the attacker can effortlessly revise upward or downward her demands. Similarly we assume that the benefits at stake are completely divisible. A leader responsive to domestic political concerns, however, is likely much less flexible. We also make fairly simple assumptions about each side's probability of victory in battle. In reality, the disputants' probability of success is likely affected by what happens on the battlefield and by what military strategies they choose. Further, we have not included in this model the potential for third parties to intervene. The anticipation of third-party intervention not only influences the disputants' strategies but also impacts their probability of success in the case of intervention. We do not deny the importance of these areas and intend to include such considerations into the model in the near future. We offer this model as a base case from which we can measure the impact of these other factors.

Despite its simplicity, we contend that this model makes an important contribution to our understanding of international conflict because it provides a unified theory of war onset and war termination. The equilibrium specify not only if a war starts, but when it ends, and the terms on which it terminates. Since the duration and the terms of the war depend on which defender the attacker actually faces (and that fact is unknown) and on the battle history, the duration of the war and the terms of settlement are to some degree unpredictable. We have provided, however, several results that increase our ability to anticipate the onset, termination, and outcome of international conflict.

The model also provides a general explanation for why wars start and how they end. In the model a war starts because 1. The attacker believes her power affords her a greater share of the benefits than she currently has and thus demands some concessions from the defender and 2. The defender believes that she does not need to make as many concessions as the attacker has demanded and thus refuses to concede. The war continues so long as the attacker continues to overestimate what the defender will concede or, in the event of a retreat, to underestimate what she must give up. The war ends when the attacker's and the defender's beliefs about the defender's power converge sufficiently for the attacker to make a proposal acceptable to the defender.

The model suggests that the war itself is the mechanism by which this convergence occurs. Ironically, war lays the path to peace (Wagner 1993). If the disputants initially are uncertain about each other's abilities, then the opponent's continued willingness to fight as well as the progress on the battlefield provides considerable information about such questions. As the belligerents learn about each other through the war, negotiations become more productive as each recognizes the demands they can make or must concede to. In this depiction of war, the military is no longer an alternative to diplomacy, but instead an extension of it; the disputants fight in order to support rather than to supplant their negotiating position.

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Figure 1

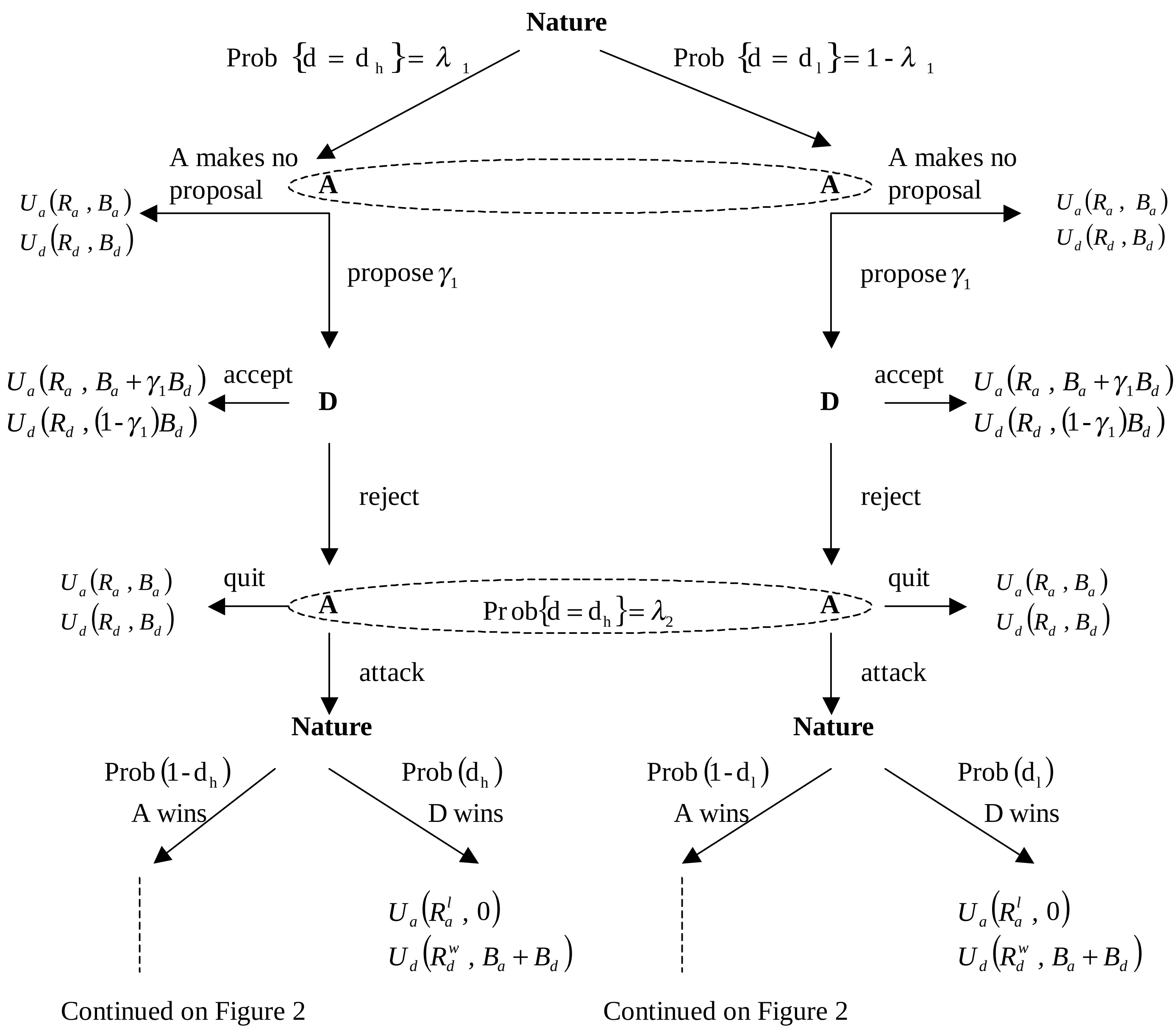
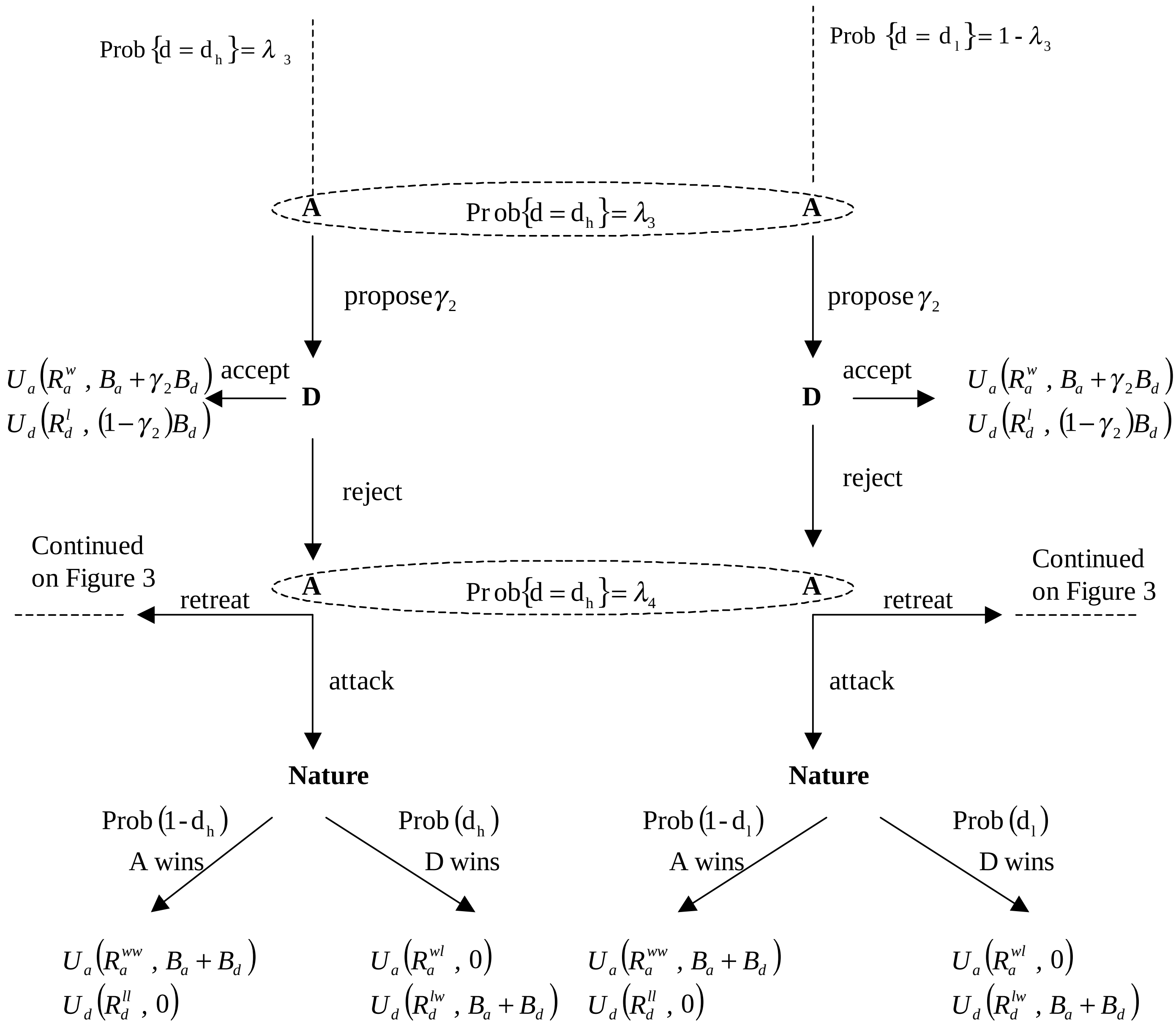
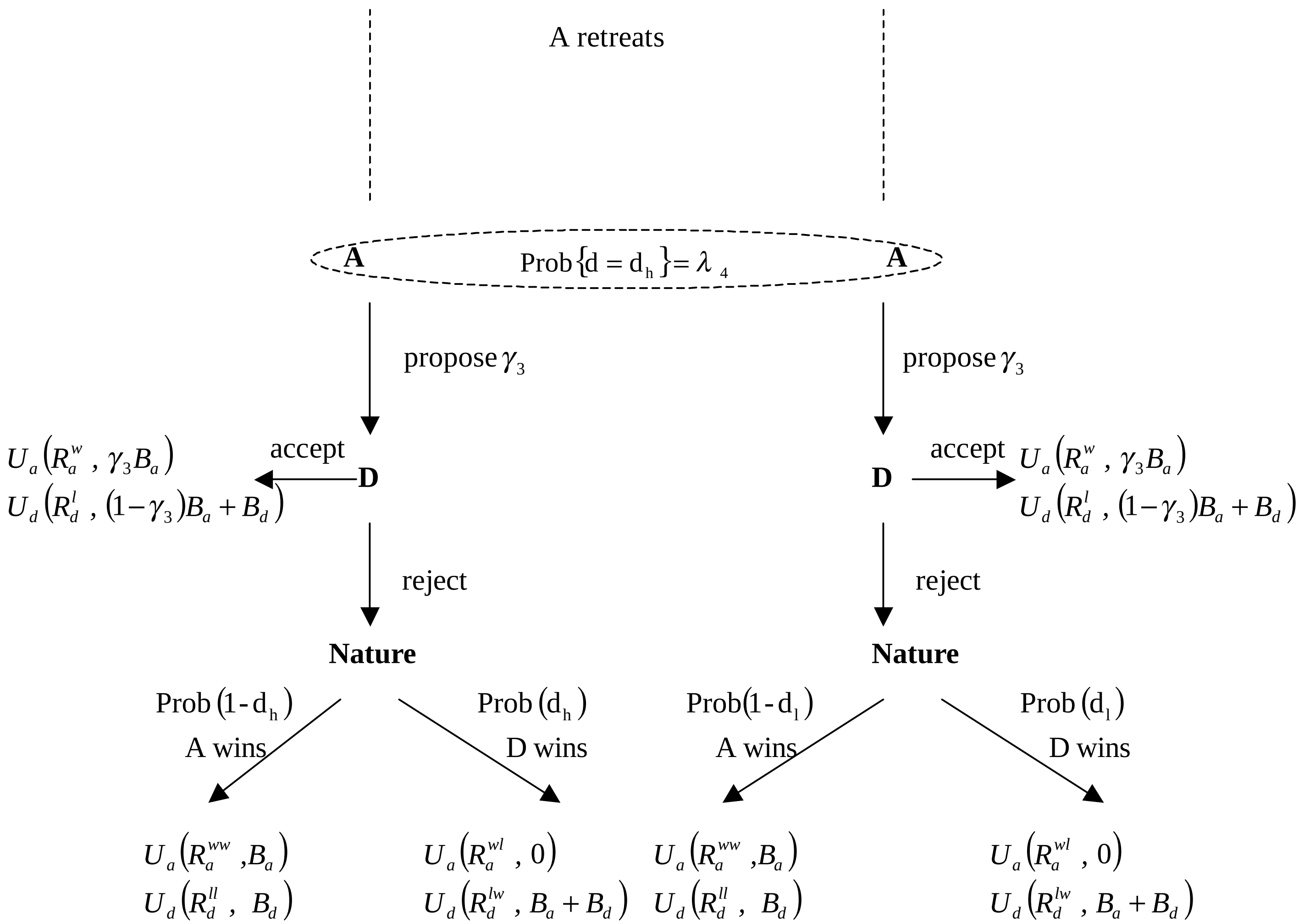

Nature
Prob {d = d_h} = λ_1
Prob {d = d_l} = 1 - λ_1
A makes no proposal
A
A
A makes no proposal
U_a(R_a, B_a)
U_d(R_d, B_d)
U_a(R_a, B_a)
U_d(R_d, B_d)
propose γ_1
propose γ_1
U_a(R_a, B_a + γ_1 B_d)
U_d(R_d, (1 - γ_1) B_d)
accept
D
D
accept
U_a(R_a, B_a + γ_1 B_d)
U_d(R_d, (1 - γ_1) B_d)
reject
reject
U_a(R_a, B_a)
U_d(R_d, B_d)
quit
A
Prob{d = d_h} = λ_2
A
quit
U_a(R_a, B_a)
U_d(R_d, B_d)
attack
attack
Nature
Nature
Prob (1 - d_h)
A wins
Prob (d_h)
D wins
Prob (1 - d_l)
A wins
Prob (d_l)
D wins
U_a(R_a^l, 0)
U_d(R_d^w, B_a + B_d)
U_a(R_a^l, 0)
U_d(R_d^w, B_a + B_d)
Continued on Figure 2
Continued on Figure 2

Figure 2



Prob {d = d_h} = λ_3
Prob {d = d_l} = 1 - λ_3
A
Prob{d = d_h} = λ_3
A
propose γ_2
propose γ_2
U_a(R_a^w, B_a + γ_2 B_d)
U_d(R_d^l, (1 − γ_2)B_d)
accept
D
D
accept
U_a(R_a^w, B_a + γ_2 B_d)
U_d(R_d^l, (1 − γ_2)B_d)
reject
reject
Continued on Figure 3
Continued on Figure 3
retreat
A
Prob{d = d_h} = λ_4
A
retreat
attack
attack
Nature
Nature
Prob (1 - d_h) A wins
Prob (d_h) D wins
Prob (1 - d_l) A wins
Prob (d_l) D wins
U_a(R_a^ww, B_a + B_d)
U_d(R_d^ll, 0)
U_a(R_a^wl, 0)
U_d(R_d^lw, B_a + B_d)
U_a(R_a^ww, B_a + B_d)
U_d(R_d^ll, 0)
U_a(R_a^wl, 0)
U_d(R_d^lw, B_a + B_d)

Figure 3


A retreats
A
Prob{d = d_h} = λ_4
A
propose γ_3
propose γ_3
accept
D
D
accept
U_a(R_a^w , γ_3 B_a)
U_d(R_d^l , (1−γ_3)B_a + B_d)
U_a(R_a^w , γ_3 B_a)
U_d(R_d^l , (1−γ_3)B_a + B_d)
reject
reject
Nature
Nature
Prob(1-d_h)
A wins
Prob(d_h)
D wins
Prob(1-d_l)
A wins
Prob(d_l)
D wins
U_a(R_a^ww ,B_a)
U_d(R_d^ll , B_d)
U_a(R_a^wl , 0)
U_d(R_d^lw , B_a + B_d)
U_a(R_a^ww ,B_a)
U_d(R_d^ll , B_d)
U_a(R_a^wl , 0)
U_d(R_d^lw , B_a + B_d)